

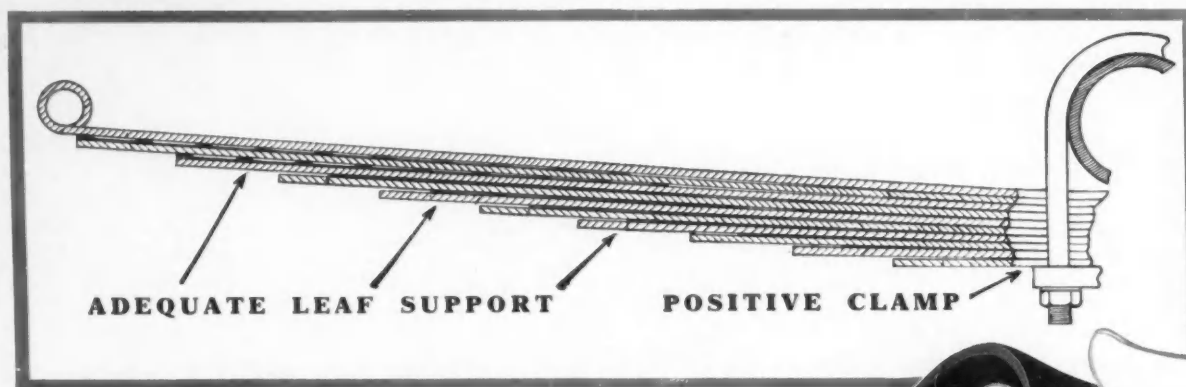
MAY 4

S·A·E JOURNAL

10TH
NATIONAL
AERONAUTIC
MEETING

MAY 1931

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S·A·E· JOURNAL

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The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.



ON THE AIRWAYS TO-DAY

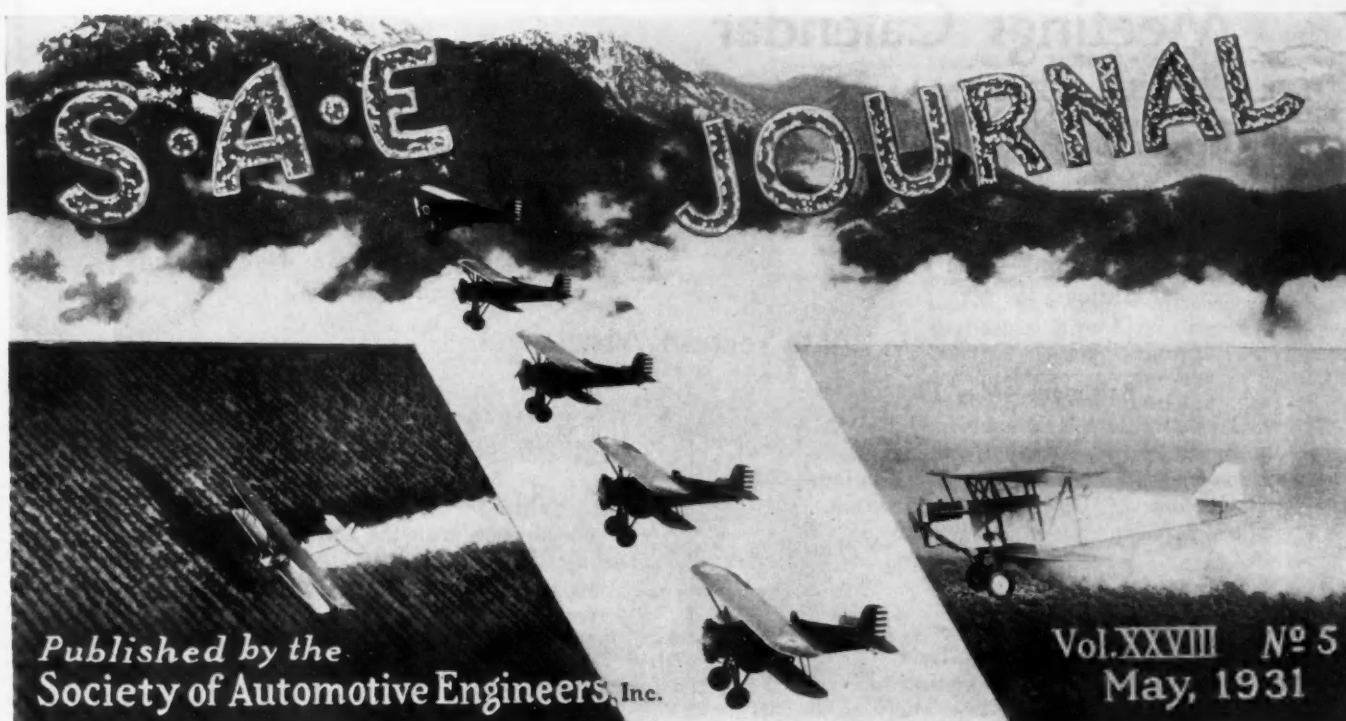
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Data on Aviation Are Cumulative

Aeronautic Meeting Features Flight Testing, Autogiro, Engines and Fuels—Manly and Wright Medals Presented

AIRCRAFT-INDUSTRY progress was given further impetus at each of the six sessions of the 19th Aeronautic Meeting held April 15 and 16 in Detroit in conjunction with the Aeronautical Chamber of Commerce and the Detroit Section of the Society. The program for the technical sessions was comprehensive in scope and induced more than 350 members and guests to register. The aircraft banquet on Thursday evening, April 16, was the concluding feature. The 1931 National Aircraft Show, managed by Ray Cooper and in progress April 11 to 19, afforded to the members who attended it many examples of up-to-date aircraft design as well as providing them with thrills when witnessing the flights of the numerous types of planes exhibited.

Airplane and Fabric Tests Cited

Commercial flight-testing ranges from tests made after airplane parts have been changed to flights made to secure data on which to base major airplane-design changes, according to Lieut. Com. E. W. Rounds, of the Bureau of Aeronautics, who presented the first paper at the opening session held

Wednesday morning, April 15, under the chairmanship of T. P. Wright, of the Curtiss Aeroplane & Motor Co. The paper is published in this issue beginning on p. 511.

Some major subjects in the discussion were the determination of stalling speed and landing speed and their relation to each other, and the method of determining the lowest possible speed of an airplane. Commander Rounds stated that the suspended-bomb method is the most accurate way of determining low speed and landing speed. But he believes that by using intelligently a carefully calibrated air-speed indicator, the landing speed can be obtained within an accuracy of less than 1 m.p.h. He said also that the method of determining landing speed by reading the air-speed indicator at the instant of touching the ground is not always feasible, particularly in some single-seat airplanes in which the pilot is occupied with the problem of landing rather than watching the indicator.

Past-President Edward P. Warner made numerous comments relating to minimum speed, landing speed, methods of measuring these speeds, and the

specifications for gross load when calibrating an air-speed meter. Commander Rounds replied in detail. The comments and replies will be published later. An interesting description was given by one discussor of the photographic method of measuring landing speed at present used successfully in Germany. This provoked discussion whether the photographic method is most satisfactory in that it eliminates the personal equation, or whether personal observation and individual judgment should continue to be essential for accuracy.

Fabrics Used in Aeronautics

C. J. Cleary, of the Army Air Corps, analyzed the subject of fabrics in the second paper presented. He said that just so long as textile materials are used as stressed members—as for wing coverings, semi-rigid and non-rigid balloon envelopes and parachute canopies—they must necessarily be subject to the same careful scrutiny as other structural materials with reference to the design and performance of the fabricated article. The four natural divisions of textile fibers are (a) animal, such as wool and silk; (b) vege-

Meetings Calendar

National Meetings of the Society

Milwaukee Production Meeting—May 7 and 8

Hotel Schroeder, Milwaukee
Sponsored by Milwaukee Section and National Production Activity

Summer Meeting—June 14 to 19

White Sulphur Springs, W. Va.

20th National Aeronautic Meeting—Sept. 1 to 3

Hotel Statler, Cleveland
In Conjunction with the National Air Races

Transportation Meeting—Nov. 10 to 12

City of Washington

May Section Meetings

Baltimore—May 15

Lord Baltimore Hotel; Dinner 6:30 P. M.; Entertainment

Developments in High-Compression Engines—Earl Bartholomew, Director of Research, Ethyl Gasoline Corp.

Canadian—May 20

Royal York Hotel, Toronto

The New Airplane Ski—R. G. Perry, General Manager, Colonial Coach Lines, Ltd.

The Ottawa Laboratories in Relation to Aviation—Prof. J. H. Parkin, Assistant Director, Department of Physics, National Research Council of Canada

Aviation—An address by Lieut.-Col. W. A. Bishop, V.C., D.S.O., M.C., D.F.C., Toronto

Chicago—May 5

Midland Club, 172 West Adams Street; Dinner 6:30 P. M.; Entertainment

Factors Controlling Engine Carbon Formation—John O. Eisinger, Laboratory Engineer, Standard Oil Co. of Indiana

Exhaust and Monoxide Gases—Arlyn H. Vance

Cleveland—May 11

Hotel Statler; Dinner 6:30 P. M.; Entertainment
Description and Use of Stroboglow—L. R. Quarles, Research Laboratories, Westinghouse Electric & Mfg. Co.

Highways of Cuyahoga County—Dr. J. Gordon Mackay, Director, Regional Highway Bureau

Detroit—May 11

Book-Cadillac Hotel; Dinner 6:30 P. M.; Entertainment

Race Cars for 1931—F. S. Duesenberg, Vice-President, Duesenberg Inc.

Factors Affecting Efficiency of Combustion—D. M. Pierson, Assistant Chief Electrical Engineer, Chrysler Corp.

New Instrumentation for Measuring Efficiency of Combustion—Dr. Miller Reese Hutchison, Hutchison Laboratory

Indiana—May 22

Hotel Severin, Indianapolis; Dinner 6:30 P. M.; Entertainment

Races of Other Days versus the 500-Mile Race—Bert Dingley, Vice-President, Stutz Motor Car Co.

Metropolitan—(?)

Date and location undecided

F. Van Rossen Hoogendyk, engineer, naval architect and designer of small Diesel engines, will talk on Diesel engines

Milwaukee—May 7 and 8

Hotel Schroeder; Spring Production Meeting in cooperation with the National Society

Technical sessions at 10:15 A. M., and 1:30 P. M., each day, with Dutch Lunch and special entertainment on May 7, at 6:30 P. M., and the Production Dinner on May 8, at 6:30 P. M., at which Dr. E. A. Ross, University of Wisconsin, will talk on Aspects of Economical Production as They Affect Present Conditions

Northwest—May 8

New Washington Hotel, Seattle, Wash.; Dinner, 6:30 P. M.; Entertainment

Scientific Adjustments of Carbureters—Prof. F. G. Baender, Head of Mechanical Engineering Department, Oregon State College

Oregon—(?)

Multnomah Hotel, Portland; Dinner 6:30 P. M.; Entertainment

Philadelphia—May 13

Demonstration of the Autogiro at one of the flying-fields, location undecided, followed by a dinner at 6:30 P. M., at which a paper on the Autogiro will be given by Agnew E. Larsen, Chief Engineer, Autogiro Co. of America

Pittsburgh—May 21

Annual Frolic—Location undecided

Southern California—May 8

Alexandria Hotel, Los Angeles; Dinner 6:15 P. M.; Entertainment

A Résumé of Three Years of Reducing Costs of Operating Automotive Equipment—James C. Bennett, Manager, Automotive Department, Associated Oil Co.

Fleet Maintenance—Doyl Rishel, Los Angeles Railway Co.

Fleet Maintenance—Thomas H. MacKechnie, Automotive Division, Southern California Telephone Co.

Bearing Lubrication—Virgil Weiss, Lubricating Engineer, Standard Oil Co. of California

Wichita—May 8

Allis Hotel; Dinner 6:30 P. M.

Design Characteristics of Aluminum Alloys—Paul Thornton, Sales Engineer, Aluminum Co. of America



FIRST AIRCRAFT-SESSION CHAIRMAN AND SPEAKERS

(Left to Right) T. P. Wright, of the Curtiss Aeroplane & Motor Co., Chairman; Lieut.-Com. E. W. Rounds, of the Bureau of Aeronautics of the Navy Department, Who Presented a Paper on Commercial Flight-Testing; and C. J. Cleary, of the United States Army Air Corps, Who Gave a Paper on Fabrics in Aeronautics

table, such as cotton and linen; (c) mineral, of which asbestos is the only important example; and (d) artificial, such as rayon.

Some of the tests made are those for tensile strength, performance when subjected to dead loading, and porosity. For parachute silk they are for minimum tensile-strength, maximum unit-weights, tearing strength across each system of threads and the rate of air-flow through a unit area of the cloth at a specified pressure. Brief descriptions were given of the test methods and of the testing equipment.

Replying to Chairman Wright in the discussion, Mr. Cleary stated that wing-

covering cloth had been continuously exposed for three years on an airplane which had no protection, and that then the tensile-strength properties of the cloth were still equal to the minimum requirements of new cloth according to the specifications. In his opinion this result was chiefly because the material was protected by pigmented covering. He remarked that there is a change in the physical properties just after a new fabric has been doped, but that this change has so far not been defined. Other points covered related mainly to the effects of doping fabric and to the degree of tautness to which a fabric should be stretched.

Aircraft Progress Heralded

Recent Autogiro Refinements and Airplane Loading Conditions Analyzed at Second Session

FURTHER developments of the Autogiro were summarized by W. Laurence LePage, of the Kellett Aircraft Corp., at the Session held Wednesday afternoon, April 15, and R. V. Rhode, of the National Advisory Committee for Aeronautics, presented another paper entitled Applied Load-Factors and Their Correlation with the Load Distribution for Airplanes. Dr. George W. Lewis, of the foregoing Committee, was Chairman.

Autogiro Applies Basic Principles

Mr. LePage said regarding Autogiro development that we are inclined to view new ideas in aeronautics as always involving new fundamentals, but his plea was to consider this unique machine and its theory as nothing distinctly new fundamentally, thinking of it instead as a device new in its capability for application of existing and

long-proved fundamentals. Thus, he said, we really attain the mental attitude which enfolds the picture of Autogiro theory and development as something far less mystic and far more practical than we might otherwise believe it to be.

After showing and explaining a diagram of the rotor blade of an Autogiro of conventional form as a basis for discussing recent developments, Mr. LePage analyzed these in considerable detail with regard to dynamic and static balance, lifting power and the effect of the rotor system and its control. He also considered the effect of the fixed wing in conjunction with the effect of the rotor at different speeds.

Mr. LePage urged engineers to adopt an attitude toward all aircraft design which is sufficiently open-minded for them to be willing to see apparently astonishing and novel developments

come onto the horizon and be proved practical, without feeling that because they are novel they necessarily cannot be right.

Statements made by Mr. LePage in answering the numerous questions in the discussion relating to performance were that the Autogiro performs exactly like an airplane, that present Autogiros are flying with extremely low disc-loadings and that four rotor-blades were chosen after extensive experiments with more and with fewer blades. Other technical refinements were debated pro and con in regard to landing, landing-gear, air speed of the machine and some still unknown characteristics of the effects of the rotor blades in their relation to the fixed wing, and the position of the center of gravity relative to the center of rotation.

Airplane Loading Conditions Analyzed

Richard V. Rhode's paper was supplementary to the paper on Weight Saving by Structural Efficiency prepared by Charles Ward Hall and published in the S. A. E. JOURNAL for October, 1930, p. 466. Mr. Hall's paper was confined to a discussion of the design; Mr. Rhode's paper treated the loading conditions, because their sound establishment is the foundation of a safe and efficient structure. This simple truth is sufficient cause to justify extensive study of the underlying principles; but, in addition, with increasing performance and maneuverability, structural failures are occurring which can be traced definitely to inadequate strength requirements and the study of the loading conditions becomes a problem of immediate practical importance.

Mr. Rhode's analysis was confined to the loading conditions on the wings of airplanes in the non-acrobatic category; (a) the total loads acting and (b) the distribution of these loads over the surface. In conclusion, he remarked that there seems to be no reason why design load-factors for non-acrobatic airplanes will need to be increased greatly over those now used, but it is evident that load-factor schedules and design conditions can be put on a more rational basis than they are on at present, and this probably will be done when the data become extensive enough to justify such a move.

Ralph Upson suggested three rather than two groups of load factors; that is, the determination of the loading conditions, the choice of airplane characteristics to suit these conditions best, and the design of the structure to carry the resulting loads, stating his reasons in some detail. Edward P. Warner discussed the absorption of forces due to vertical currents of air and said also that the horizontal currents, although they may be thought to be of less importance, may not be entirely negli-

gible. Mr. Rhode replied that when an airplane goes up and acceleration records are obtained it is impossible to determine whether the so-called "bumps" are due to horizontal or to vertical pulsations. With increasing speed of flight the effect of the horizontal pulsations becomes relatively of

less importance and, he continued, from a theoretical viewpoint, the effects of the horizontal currents are very much less than the effects of the vertical currents on account of their different intensity. He stated that reliable information on this subject is extremely limited.

which makes it difficult to analyze and attack new market conditions; he is doubly unfortunate because the very nature of his product requires that he know the market trends long before the airplane manufacturer knows them. The development to production status of a new engine-model is a considerably larger undertaking in both time and money than is the production of a new airplane.

The present light-airplane trend was characterized by Mr. Insley as an effort to enlarge the field of private ownership of airplanes by reaching the older generation, which is not yet sufficiently "sold" on aviation to invest in full-sized airplanes at current prices, and the younger generation which accepts air travel at face value but is financially unable to buy the cheapest airplanes heretofore available. It is therefore not surprising that no two analysts agree entirely on the requirements.

J. H. Geisse discussed some of the relative merits of the two-stroke-cycle engine and the four-stroke-cycle engine with regard to fuel and oil consumption, and others participated in discussing this subject.

Spark-Plugs Analyzed

Mr. Paulson dealt mainly with spark-plugs constructed with mica insulation because they are in more general use with the large-scale commercial operators and the Government Air Services, particularly where the engines are large and the brake mean effective pressures are relatively high. He illustrated the different types of spark-plug with lantern-slides and described the construction of spark-plugs insulated with mica as well as mentioning the difficulties which must be overcome to make full use of its extremely high dielectric strength, mechanical strength, resistance to mechanical shock and machining qualities. The use of radio on aircraft has brought new problems to the manufacturer of ignition equipment for aircraft, he said. To prevent the interference of ignition with radio reception of the voice complete shielding of the ignition system, spark-plugs included, is the generally accepted solution.

Gustav P. Toews said in the discussion that classification of spark-plugs according to their relative suitability for use in Navy service engines has been in progress at the aeronautical engine laboratory of the Naval Aircraft factory at Philadelphia since 1922. The qualities investigated include ignition, fouling, starting ability, durability, fire hazard, gap burning, and gas tightness.

H. K. Cummings called attention to the study during the last two years at the Bureau of Standards on ignition problems, which is still in progress. It is hoped thereby in a basic way to devise tests which will yield definite in-

Aircraft Engines Featured

Two Engine-Types Analyzed and Suitable Spark-Plugs Considered at Aircraft Session

THE SESSION held Wednesday evening, April 15, under the chairmanship of Wesley L. Smith, featured aircraft engines and spark-plugs. The first paper was on High-Temperature Liquid-Cooled Engines, by Arthur Nutt of the Wright Aeronautical Corp.; the second, on Low-Powered Light Engines, by Robert Insley, of the Continental Aircraft Engine Co.; and the third, on Spark-Plugs for Aircraft, by G. M. Paulson, of the B. G. Corp.

Mr. Nutt said in part that considerable interest has been shown during the last year or two in the use of high-temperature liquid coolant for aircraft engines. Both evaporative cooling, which has been used experimentally on automobile and aircraft engines, and the use of high-boiling-point liquid have been considered. The reasons for increasing the temperature of the coolant are weight saving, higher air-speed of the airplane by reduction of drag, the possibility of decreasing fuel-consumption, and the simplification of controls.

In conclusion, Mr. Nutt stated that liquid-cooled engines of large powers have a definite field in large patrol-

boats, transport airplanes, various military airplanes and dirigibles. They are small in frontal area, compact, permit good visibility and, with their low specific fuel-consumption, which has been demonstrated, the weight of the powerplant plus the fuel is very favorable and becomes more favorable the greater the range of the aircraft is.

Mr. Nutt stated in the discussion that the tests are only about half completed. He considers loss of heat to the water-jackets very important and remarked that, for example, if engine power is doubled it is difficult to determine what amount of heat will be lost in the water-jacket, this being information that is necessary when designing radiators for different types of airplane. The effect of air speed on the cooling is also problematical. Other discussion related to the allowable pressure in the cooling system and to the types of cooling system.

Low-Powered Engines

Mr. Insley said in part that the aircraft-engine manufacturer is handicapped initially because he is twice removed from the ultimate market,



SECOND AIRCRAFT-SESSION CHAIRMAN AND SPEAKERS

(Left to Right) Dr. George W. Lewis, Director of Aeronautical Research, National Advisory Committee for Aeronautics, Chairman; W. Lawrence LePage, of the Kellett Aircraft Corp., Who Presented a Paper on Further Developments of the Autogiro; and R. V. Rhode, of the National Advisory Committee for Aeronautics, Author of a Paper on Applied Load Factors and Their Correlation with the Load Distribution

formation as to the merits of ignition apparatus, he said. The two phases of this study are the effectiveness of different sparks in producing ignition and the reliability of different sparks or different sparking apparatus. In this

manner it is hoped that a useful laboratory tool will be developed for determining in advance the merits of electrode materials and the reliability and effectiveness of different spark characteristics.

in service-maintenance programs, the basic responsibility rests upon the airplane manufacturer to provide throughout his product a complete system of corrosion protection which, while it may not outlast the airplane, will prevent corrosion for several years and also furnish a good foundation on which the operator can overhaul at the minimum expense.

Continuing, Mr. Milburn stated that protective coatings consist of paints, oils and greases, and chemical, or electro-chemical coatings. He discussed also metallic, chemical and electro-chemical coatings, corrosion prevention by design and by manufacturing processes, and corrosion tests.

In the discussion, Lieut. Clarence H. Schildhauer outlined the German methods of protection against corrosion as he had observed them at test flights of the Dornier Do-X over Lake Constance in Europe. In his opinion, no

Hull Models and Corrosion Studied

Amphibian-Hull Design-Method Outlined and Means for Aircraft Corrosion-Prevention Cited

A NOVEL method of studying flying-boat hull models on the Housatonic River in Connecticut was described by Igor Sikorsky at the session held Thursday morning, April 16. Past-President Edward P. Warner was chairman.

Mr. Sikorsky said in part that the motorboat used for towing the hull models was capable of speeds up to 35 m.p.h., and tests were made to determine its various speeds as precisely as possible. The testing equipment consisted of a simple lever attached to a torsion tube which was mounted in turn on antifriction bearings, this being rigged to extend at a 90-deg. angle to the boat so that its outboard end was 12 ft. from the center line to provide ample clearance and allow the models to be free from disturbance created by the boat. To the end of the torsion tube another lever was attached, and this was connected to a calibrated spring-balance. The lever on the outboard end of the torsion tube was connected to the model by a light towline attached to the bow of the model hull. This arrangement permitted the towing of models up to 80 lb. in weight with considerable success.

For an extensive scientific research, Mr. Sikorsky does not believe that the towing method can equal the accuracy and other qualities of tests made in the model-testing basin of the Bureau of Aeronautics, yet he is convinced that it may furnish, quickly and with small expense, valuable and sufficiently accurate information for the practical use of the designer.

Most interesting motion pictures were shown, in connection with Mr. Sikorsky's paper, of tests of different types of hull models at various speeds and under varied conditions. These illustrated vividly how changes in design affect the performance and how the model's performance suggests changes in design. In reply to questions, the author discussed the characteristic spraying of water from different parts of the hull, how spray may interfere with the landing-gear and with the propeller, and the methods whereby changes in design are made to prevent these difficulties.

Lessiter C. Milburn's paper dealt

mainly with means for protecting aluminum from corrosion. He analyzed the theory of corrosion and emphasized the importance of prevention, stating also that the chief effect of corrosion is reduction of strength and elasticity. He said further that, while corrosion prevention should be a prominent item



PRINCIPAL PARTICIPANTS IN FIRST AIRCRAFT-ENGINE SESSION

(Upper Left) Arthur Nutt, of the Wright Aeronautical Corp., Author of a Paper on High-Temperature Liquid-Cooled Engines. (Upper Right) G. M. Paulson, of the B. G. Corp., Who Gave a Paper on Spark-Plugs for Aircraft
(Lower Left) Wesley L. Smith, of the National Air Transport, Chairman of the Session. (Lower Right) Robert Insley, of the Continental Aircraft Engine Co., Who Presented a Paper on Low-Powered Light Engines

great attempt is made to prepare the metal to resist corrosion, and he stated that Dr. Dornier does not believe that the anodic method is the right one for

heated rivets be quenched quickly. His company believes in the necessity for proper heat-treating, for properly preparing the metal for paint, and for se-

tion gasoline; *B*, sample *A* plus 10 per cent of benzol; *C*, a sample of straight-run Smackover gasoline containing about 10 per cent of Midcontinent gasoline; *D*, sample *C* plus 30 per cent of benzol; and *E*, a sample of 100 per cent of cracked gasoline from a Midcontinent crude.

Knock-Testing Methods

The series No. 30 knock-testing engine of the Ethyl Gasoline Corp. was employed in all tests. Among the other control conditions, the engine was operated at a speed of 6000 r.p.m. and a jacket temperature of 300 deg. fahr. Determinations were made of the octane number of each fuel and also of the amount of tetraethyl lead necessary to make each test fuel equal an octane number of 87. For fuels *A*, *B* and *D*, representing straight-run fuels and benzol blends, the results of the different laboratories agreed to an average deviation of about one-half an octane number, and a maximum deviation of about one octane number. For sample *E*, as was to be expected, the agreement is not so good. The effect of moderate variations in compression pressures was small and no definite effect of air temperature or humidity was shown. The fuels showed great sensitivities to changes in carburetor float-bowl level. The fuel-air ratio must be adjusted with extreme care.

Less Rigid Procedure for Other Tests

Whereas the detonation tests reported by Dr. Edgar were carried on in accordance with a rigid procedure of tests covering every feature in detail, the tests reported by H. K. Cummings and D. B. Brooks, of the Bureau of Standards, were conducted in every case in accordance with the method preferred by each of the cooperating laboratories and no attempt was made to control the procedure. Results were obtained on five fuels in seven cooperating laboratories at speeds of 600 and 900 r.p.m., and jacket temperatures of 212 and 330 deg. fahr. The fuels were *A*, 100 per cent of Stanavo gasoline; *B*, 100 per cent of Midcontinent D.A.G.; *C*, 86 per cent of Stanavo gasoline plus 14 per cent of benzol; *D*, 50 per cent of Stanavo gasoline plus 50 per cent of Midcontinent D.A.G.; and *E*, Stanavo gasoline plus 1 ml. of tetraethyl lead per gal.

The results indicate that when a specific method is used a multicylinder engine may give an octane-number rating within a range of two octane numbers and emphasize, as indicated by several discussers of the paper, that we have a long way to go in arriving at a proper procedure for determining the knock rating of aviation fuels. A comparison of the two papers shows that, where different laboratories use identical procedure, uniformity of results can be attained to



CHAIRMAN AND SPEAKERS AT THE SESSION ON AMPHIBIANS AND SEAPLANES

(Top) Past-President Edward P. Warner, Editor of *Aviation*, Who Presided as Chairman. (Left) Igor Sikorsky, of the Sikorsky Aviation Corp., Author of the Paper on A Novel Method of Studying Flying-Boat Hull Models. (Right) Lessiter C. Milburn, of the Glenn L. Martin Co., Who Gave a Paper on Corrosion Prevention

corrosion prevention. It was brought out by Conrad Nagle that, when heat-treating rivets to prevent rivet corrosion, it is very important that the

curing the adherence of paint. He also cited instances of the good performance of Alclad in resisting corrosion under severe conditions.

Aviation-Fuel Developments

Detonation - Test, Knock-Testing-Precision and Other Data on Aviation Fuels Presented

THE LARGE attendance at the session held Thursday morning, April 16, was characteristic of former detonation sessions. As chairman, Dr. H. C. Dickinson, of the Bureau of Standards, pointed out that attention was first attracted to the importance of the detonation characteristics of aviation fuel several years ago, when it was discovered that various fuels behaved differently at different altitudes. It was found that the use of a non-detonating fuel overcame these difficulties. This action of the fuel in power production, rather than the noise from detonation, led to the first attempt to introduce a non-detonating fuel for aviation purposes.

Dr. Graham Edgar, director of research of the Ethyl Gasoline Corp.,

in his paper on Precision of High-Temperature Knock-Testing, said that the Army Air Corps, in adopting its specification for antiknock gasoline for use under conditions of high jacket-temperatures, found that relatively little information was available concerning the precision of the test, or the agreement to be expected among different laboratories. The data and results presented in his paper represent the outcome of a short cooperative program arranged among a group of six laboratories including that of the Army Air Corps, the two laboratories of the Ethyl Gasoline Corp., and the three laboratories of the Standard Oil Cos. of California, Indiana and New Jersey. The fuels studied were *A*, a sample of straight-run California avia-

a high degree. Whereas, even though the same engine be used, variations in procedure will bring about a wider spread in results, all of which empha-

sizes the need for uniform standard procedure in detonation testing even though such procedure may require considerable and frequent revision.

Three Aeronautical Phases

Superchargers, Lubrication Effects, and Airplane Fuel-Line Temperatures Discussed

THREE important papers were presented at the concluding technical session held Thursday afternoon, April 16, the first being on Superchargers and Supercharging, by Oscar W. Schey. It is printed in full in this issue beginning on p. 524. F. L. Prescott and R. B. Poole, of the Army Air Corps, chose as their subject Bearing-Load Analysis and Permissible Loads as Affected by Lubrication in Aircraft Engines. The third paper was by Dr. O. C. Bridgeman and H. S. White, of the Bureau of Standards, and C. A. Ross of the Army Air Corps. It was entitled Airplane Fuel-Line Temperatures. Arthur Nutt, of the Wright Aeronautical Corp., was chairman.

In the discussion, H. K. Cummings stated that Mr. Schey's paper was read at the Bureau of Standards with great interest and that the first part is quite in line with experimental work which the Bureau has been doing for the last five years. This work checks to a very satisfactory degree with the results presented by Mr. Schey, he continued, and went on to explain the few points of difference between the Bureau's and Mr. Schey's results.

Sanford A. Moss presented prepared discussion and said that, for the case of an engine purposely designed to withstand so-called "boosting" at sea level, as is now becoming customary, the curves in the latter part of the paper are very illuminating. The investigations show that brake mean effective pressures of over 200 lb. per sq. in. can be maintained without difficulty by use of a sufficient amount of supercharging. Most engine builders are steadily increasing this boosting or supercharging at sea level, and the advantages stated in the paper show that this tendency is bound to continue.

Other subjects discussed were specific fuel-consumption in its relation to supercharging, the effect of increase in size of the radiator on a supercharged engine as regards head resistance, compression ratios, and the determination of brake horsepower.

Aircraft-Engine Lubrication Effects

Messrs. Prescott and Poole presented the results of analyses of the leading aircraft engines, together with graphical and analytical methods of analyzing bearing loads. The analytical method given was derived from the long, tedious graphical method, and was

presented for the first time in this paper. This method enables bearing loads to be calculated quickly and with sufficient accuracy for all engine-design purposes. The paper was replete with statistical, tabular and analytical data.

Dr. H. C. Dickinson criticized the use of the conventional pv factor as a criterion of the carrying capacity of a bearing because such use is misleading. The only use of the pv factor is as an indication of the amount of heat that is generated in the bearing, he said,

and protested against the use of the factor as an index of carrying capacity. Mr. Prescott replied that the purpose regarding the pv values as stated in the paper was to show the wide discrepancies that were found in practice and not to uphold the use of the pv value in such cases. It is some kind of measure of the amount of heat that is generated in a bearing, he remarked, and is therefore an indication of how much oil must be put through the bearing to cool it.

Airplane Fuel-Line Temperatures

In the paper on fuel-line temperatures the authors stated that any general conclusions from the limited amount of data obtained are difficult to make. The airplanes investigated cover in a general way a number of types which are of interest and indicate several things which are suggestive. The one outstanding point which is apparent in connection with these flights is that the temperature of the fuel in the feed system tends to drop



THOSE WHO TOOK LEADING PARTS IN THE SESSION ON AIRCRAFT FUELS

(Top) H. K. Cummings and Donald B. Brooks, of the Bureau of Standards, Co-Authors of the Paper on Detonation Tests on Aviation Fuels. (Below) Dr. H. C. Dickinson, Chief of Heat and Power Division, Bureau of Standards, Session Chairman; and Dr. Graham Edgar, of the Ethyl Gasoline Corp., Who Presented a Paper on Precision of High-Temperature Knock Testing

very slowly as the airplane climbs. This is very serious in hot weather for, if a plane stands in the sun for some time before taking off, high fuel-temperatures may be expected and hence vapor lock may occur when many thousands of feet of altitude are

reached, if not before. The remedy appears to be two-fold: Either fuel tanks should be so installed as to assure good heat interchange with the atmospheric air, or small fuel-radiators placed in the airstream should be employed.

welcomed the guests on behalf of the Section, whose cooperation was an important element of the success of the banquet.

"Senator" Ford, official humorist, provoked approximately 110 laughs in 24 min., which establishes a lighter-than-air record.

A list of those who attended the banquet would include a great majority of leaders in the aeronautical pursuits of this Country. Among these, the following, who sat at the Speakers' Table, were introduced by Mr. MacCracken, in addition to Dr. O. C. Bridgeman, Dr. George W. Lewis, Edward P. Warner and T. P. Wright, already mentioned in this account: Ray Cooper, manager of the National Aircraft Show; P. J. Kent, Chairman of the Detroit Section, S.A.E.; E. E. Aldrin, in charge of the aeronautic division of the Standard Oil

Hunsaker Addresses Banquet

Unusually Distinguished Gathering Told of Operating Plans for Lighter-than-Air Craft

CLIMAXING the Aeronautic Meeting, members of the Society and the Aeronautical Chamber of Commerce, over 300 in number, listened at the Aircraft Banquet to J. C. Hunsaker, vice-president of the Goodyear-Zeppelin Corp., as he revealed important plans for transoceanic operation of lighter-than-air craft.

Among many interesting items concerning the Goodyear Zeppelin project, Commander Hunsaker called attention to the fact that 160 flights of the Graf Zeppelin, including 16 that were transoceanic or of comparable character, have contributed a great deal of information upon which present plans for future transport are based. In these flights, the airship covered 145,000 miles, carried 6700 passengers, delivered many tons of mail and other material and spent about 2300 hr. in the air.

Wright and Bridgeman Honored

To T. P. Wright, vice-president in charge of engineering of the Curtiss Aeroplane & Motor Corp., the Wright Brothers Medal was presented by Edward P. Warner, Chairman of the Board of Award. In felicitating Mr. Wright for his paper, presented approximately a year ago before the Society, on The Development of a Safe Airplane, the Curtiss Tanager, Mr. Warner called specific attention to the very important contribution of Mr. Wright toward the attaining of additional efficiency and safety in flight, the principal objective sought by Orville and Wilbur Wright, in whose honor the medal is named.

Dr. O. C. Bridgeman, research associate of the Bureau of Standards, recipient of the Manly Memorial Medal, was warmly congratulated by Dr. George W. Lewis, director of research for the National Advisory Committee for Aeronautics, who, as a member of the Board of Award, presented the medal and explained that Dr. Bridgeman's work on the Effect of Airplane Fuel-Line Design on Vapor Lock is a very important contribution to airplane-engine reliability.

MacCracken Introduces Celebrities

William P. MacCracken, of MacCracken & Lee, who was Toastmaster,

was responsible for the smooth running of the banquet.

Prof. Peter Altman, of the University of Detroit and Chairman of the Detroit Section Aeronautic Division,



SECOND AIRCRAFT-ENGINE SESSION SPEAKERS

(Top) Oscar Schey, of the National Advisory Committee for Aeronautics, Author of the Paper on Superchargers and Supercharging, and Dr. O. C. Bridgeman, of the Bureau of Standards, Who Presented His Paper on Airplane Fuel-Line Temperatures (Below) F. L. Prescott and R. B. Poole, of the Army Air Corps, Co-Authors of a Paper on Bearing-Load Analysis and Permissible Loads as Affected by Lubrication

Co. of New Jersey and member of the Board of Governors of the Aeronautical Chamber of Commerce; Don Brown, president of the Pratt & Whitney Aircraft Co.; Arthur Nutt, vice-president in charge of engineering of the Wright Aeronautical Corp. and Vice-President of the Society; Igor Sikorsky, vice-president in charge of engineering of the Sikorsky Aviation Corp.; Vincent Bendix, president of the Bendix Aviation Corp. and President of the Society; the Hon. Clarence M. Young, Assistant Secretary of Commerce, in charge of aeronautics; Charles L. Lawrance, president of the Aeronautical Chamber

of Commerce and president of the Lawrence Engineering & Research Corp.; William Mayo, of the Ford Motor Co.; Glenn L. Martin, president of the Glenn L. Martin Co. and of the Martin Motors Corp.; George S. Wheat, vice-president of the United Aircraft & Transport Corp. and a member of the Board of Governors of the Aeronautical Chamber of Commerce; G. W. Vaughan, president and general manager of the Wright Aeronautical Corp., and a member of the Board of Governors of the Aeronautical Chamber of Commerce; Luther K. Ball, general manager of the Aeronautical Chamber of Commerce; A. H. G. Fokker, director of engineering of the Fokker Aircraft Corp. of America; and Clarence H. Schildhauer, of the Dornier Co. of America.

gineer in the aircraft division of the Bohn Aluminum & Brass Corp.; F. G. Shoemaker, assistant head of the powerplant section of the General Motors Corp. Research Laboratories; and A. L. Beal, engineer of the refined-oil department of the Vacuum Oil Co.

Manly Memorial Medal Awards

1928—S. D. Heron, for paper on *The In-Line Air-Cooled Engine*, presented at the National Aeronautic Meeting, Chicago, Dec. 6 and 7, 1928; published in the S.A.E. JOURNAL, April, 1929, p. 376

1929—No award

1930 — Dr. Oscar C. Bridgeman, for paper on *The Effect of Airplane Fuel-Line Design on Vapor Lock*, presented at the Semi-Annual Meeting, French Lick Springs, May 25 to 29, 1930; published in the S.A.E. JOURNAL, October, 1930, p. 444

Nominating Committees Elected

AT THE BRIEF business session held Wednesday afternoon, April 15, in Detroit, the following members were elected as a committee to nominate a Vice-President of the Aircraft Activities Committee: namely, W. L. LePage, chief engineer of the Kellett Aircraft Corp.; Ralph H. Upson, aeronautical engineer; George E. A. Hallett, research engineer of the General Motors Corp. Research Laboratories; and C. H. Chatfield, aeronautical engineer of the United Aircraft & Transport Corp., of Connecticut.

The Nominating Committee members elected at the business session held Thursday afternoon, April 16, to nominate a Vice-President for the Aircraft-Engine Activity were: Burnham Adams, engineer of the Wright Aeronautical Corp.; G. C. Brown, sales en-

Wright Brothers Medal Awards

1928 — Lieut.-Commander Clinton H. Havill, U.S.N., for paper on *Aircraft Propellers*, presented at the National Aeronautic Meeting, Chicago, Dec. 6 and 7, 1928; published in the S.A.E. JOURNAL, January, 1929, p. 17

1929—Ralph H. Upson, for paper entitled, *Wings—a Coordinated System of Basic Design*, presented at the 18th National Aeronautic Meeting, Cleveland, August 26 to 28, 1929; published in the S.A.E. JOURNAL, January, 1930, p. 15

1930—T. P. Wright, for paper on *The Development of a Safe Airplane—the Curtiss Tanager*, presented at the 19th National Aeronautic Meeting, Detroit, April 8 to 10, 1930; published in the S.A.E. JOURNAL, May, 1930, p. 543



TOASTMASTER AND SPEAKER AT THE AIRCRAFT BANQUET

(Left) The Hon. William P. MacCracken, Jr., of MacCracken & Lee, Who Introduced the Speakers and Guests. (Right) Jerome C. Hunsaker, Vice-President of the Goodyear-Zeppelin Corp., the Principal Speaker, Who Discussed Rigid-Airship Development, the Navy's New Airship, The Akron, in Particular, and Transoceanic Service

Place Your Bets on White Sulphur

S.A.E. Summer Meeting, June 14 to 19, To Feature a Technical Program of Outstanding Merit

THE THRILL that comes once in a lifetime is run a close second by the thrill that comes with an S.A.E. Summer Meeting, and above all *this* year's Summer Meeting. In view of the educational and recreational treats offered by the Summer Meeting program, it would be prudent to start your preparations now for making tracks in the general direction of the Greenbrier Hotel at White Sulphur Springs, W. Va., during the middle of this June. The exact dates of the meeting are June 14 to 19—six days to be crammed with interest-stirring events.

The praises of White Sulphur Springs need not be sung for the benefit of those who have had the pleasure of previous visits there. For those who have not, just to give a bit of tantalizing description, we will say that at this favored resort The Greenbrier and its cottages are perched 2000 ft. above sea level and are situated in a sheltered valley on the south slope of the Greenbrier Mountains. The charms of the beautiful surroundings of The Greenbrier, coupled with its unsurpassed facilities for all kinds of sports, offer an irresistible combination.

Fourteen Technical Sessions

A technical program, replete with papers embracing the interests of the Society's eight Professional Activities, has been planned for the Society's 1931 six-day Summer Meeting by the various Activities Committees, as well as the Meetings, Research and Standards Committees. The Meetings Committee, in an effort to avoid conflict between the technical and sports events, has set aside the mornings and evenings for technical sessions, leaving the afternoons free for sports.

The Meetings Committee has also planned to hold as many as possible of the usual committee meetings on the first day of the meeting, Sunday, June 14. Committee meetings that cannot be arranged for Sunday will be scheduled as dinner meetings to be held at 5:30 on the succeeding days of the week, and will be adjourned in time to permit attendance at the evening sessions. The Meetings Committee has also announced its intention of strictly adhering to a time schedule in connection with the prompt starting and ending of technical sessions.

Plans of the committees sponsoring the Summer Meeting sessions have crystallized into the scheduling of 14 technical sessions, with two, or sometimes three, papers at each session.

The subjects to be discussed at the various sessions will bring out a wealth of useful information pertaining to the basic problems that all engineers have encountered in their particular branches of automotive work.

The sessions to be sponsored by each of the Professional Activity Committees of the Society will deal with the problems peculiar to each Activity. The program will include the General Passenger-Car, Passenger-Car-Body, Motor-Truck and Motorcoach, Transportation, Aircraft, Aircraft-Engine, Chassis, Production (to be held jointly with the General Session to be sponsored by the National Meetings Committee), Engine and two Diesel-Engine Sessions. In addition to these there will be a Fuel Session, a General Development Session and a Standards Session.

At the Fuel Session, which is being sponsored by the National Meetings Committee, important research data will be comprised in several papers to be presented by men from the Bureau of Standards: namely, Fuel-Line Temperatures in 1931 Motor-Cars, by Dr. O. C. Bridgeman and H. S. White; Further Developments in Determining Gum in Gasolines, by Dr. O. C. Bridgeman and Elizabeth W. Aldrich; and The Size of Bracket and Detonation Testing, by Donald B. Brooks.

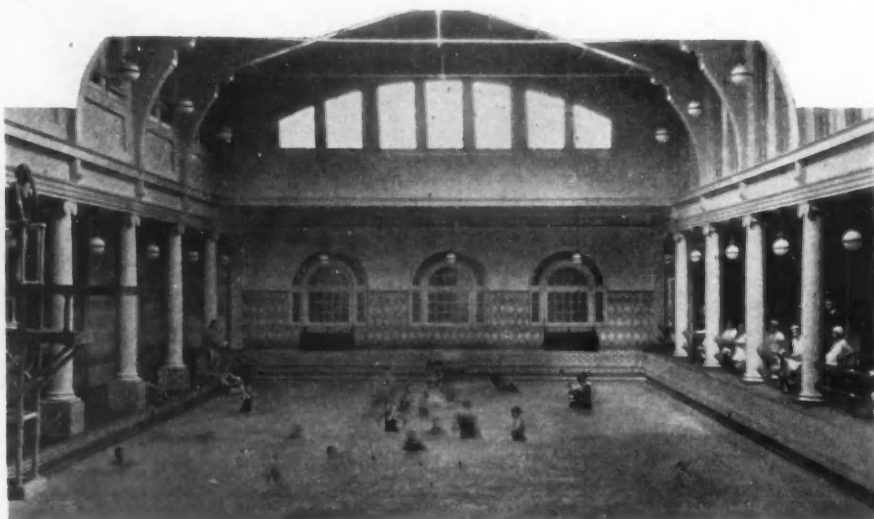
The General Development Session, also under the sponsorship of the National Meetings Committee, will feature two papers, one by D. P. Barnard, 4th, of the Standard Oil Co.

of Indiana, and the other by Herbert Chase, associate editor of *Product Engineering* and *American Machinist*. Mr. Barnard will contribute technical material of unusual value on the Physical Aspects of a Newly Developed Synthetic Lubricating Oil, and it is expected that Mr. Chase will present an analysis of The Problem of Mounting the Engine in the Rear of the Car.

The Standards Session will be sponsored by the Standards Committee and will be devoted to a discussion of the latest developments in the field of standardization.

Activities Sessions Authors and Subjects

The authors of the Summer Meeting papers scheduled for presentation at the sessions to be sponsored by the Professional Activities are men who have time and again demonstrated their unusual abilities in the automotive field. Among them are H. L. Horning, president of the Waukesha Motor Co., who will discuss the problem of the High Cost of Labor Turnover at the General Production Session; Walter T. Fishleigh, consulting engineer, who is to expound the intricacies of The Tear-Drop Car at the General Passenger-Car Session; J. Barraja Frauenfelder, consulting engineer, who has consented to present a paper at one of the Diesel-Engine Sessions on Practical Experience with Devices for Damping Torsional Vibrations; Hermann A. Brunn, president of Brunn & Co., who has undertaken to outline at the Pas-



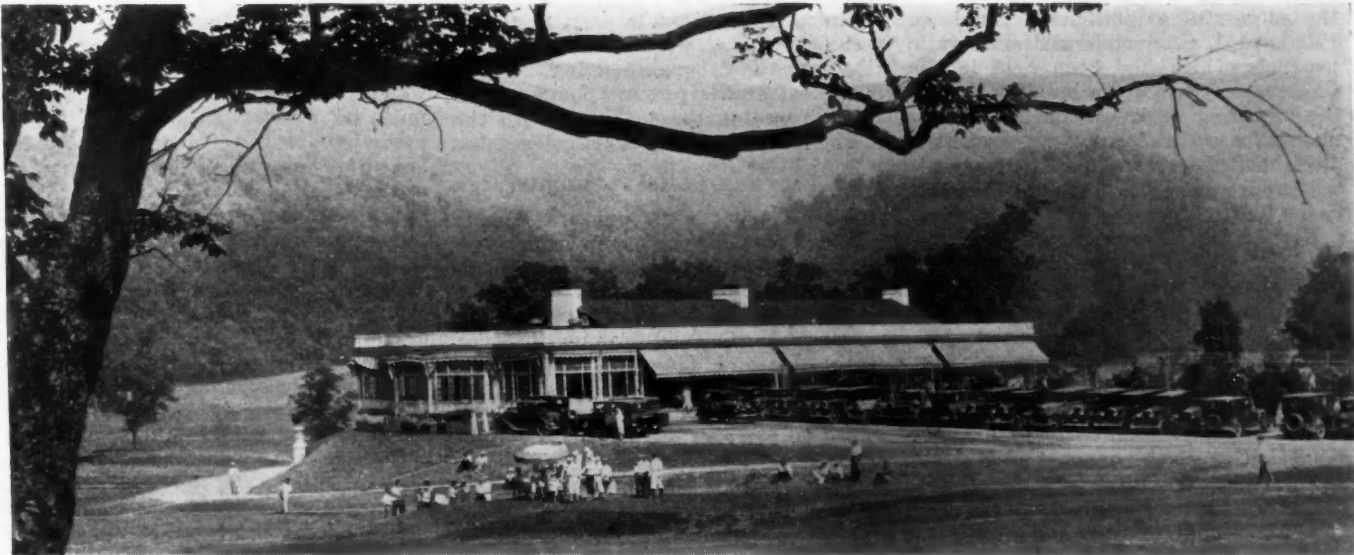
GREENBRIER SWIMMING POOL WHERE THE WATER CARNIVAL WILL BE HELD

senger-Car-Body Session his ideas concerning Comfort and Interior Appointments; Roy F. Anderson, of the Murray Corp. of America, who will tell what the body engineer wants in a chassis; J. E. Hale, of the Firestone Tire & Rubber Co., who will talk at the General Passenger-Car Session on Driving High-Speed Cars; H. C. Mougey, of the General Motors Corp., who will treat the subject of Oil Control in the Engine; Charles Hollerith, of the Automotive Fan & Bearing Co., scheduled to speak on the Reduction of Fan Noise and Power; and P. J. Kent, of the

as the knotty problems of bearing loads, riding-qualities, detonation and lubrication. Activities in sports will be many and varied. A choice is offered of teeing up for a game on one of the three wonderful golf courses maintained by The Greenbrier, serving on the excellently kept championship tennis courts, riding along the attractive bridle paths of the spacious grounds surrounding the hotel, panting up one of the many mountain trails to get a magnificent view of the Virginia hills and valleys (there are sheltered rest nooks for those who weaken on the

haps its popularity is due to the fact that a capacity for fun is the best qualification for this event, in which luck figures largely and skill is almost a total loss.

Plans for a Water Carnival during the meeting are now under way, and "Bunny" Dawe, who put over a similar event so successfully at Saranac Inn at the 1929 Summer Meeting, has accepted the invitation of Chairman N. G. Shidle, of the Meetings Committee, to handle this year's Carnival. This fact is sufficient assurance that the Carnival will be one of the things you won't



BEAUTIFUL SETTING OF THE GOLF CLUB HOUSE IN AMPHITHEATER OF GREENBRIER MOUNTAINS

Chrysler Corp., who will contribute data on Winter Starting Tests at the Engine Session.

Additional papers that have been proposed for inclusion in the Summer Meeting program comprise such timely subjects as Motor-Truck Capacity Ratings and Guarantees, Utilization of Motor-Trucks and Motorcoaches, Diesel Engines versus Gasoline Engines, Automotive Diesel Fuels, Development in Aircraft Diesel-Engine Research, Lubricating Oils, Riding-Quality Research, and The Tire Factor in Automobile Riding-Quality.

The diversity of material contained in the papers scheduled for presentation indicates the wide range of topics that will be under discussion and hints of their general appeal. To facilitate discussion of the papers at the sessions, the Society office is endeavoring to obtain from the authors copies of their papers sufficiently in advance of the meeting to allow time for having preprints made.

Varied Sports Activities

The recreational part of the Summer Meeting program offers a number of delightful ways for the busy engineer to relax and forget such things

way), going for an invigorating swim in the superb indoor pool, bending a bow for a bull's-eye at archery, or practicing any of the other attractive pastimes provided by an ingenious hostelry for the entertainment of its guests.

The only organized sports at the Summer Meeting will be a golf tournament and Field Day. The Golf Committee, under the chairmanship of A. W. Anderson, consisting of J. B. Shea and J. H. McDuffee, and Guy Motz and E. L. Carroll of the S.A.E. staff, is making arrangements for a tournament of 36-hole medal play including four flights. A Blind Par Two-Ball Sweepstakes and a Driving Contest are also being planned by the Committee. Prizes will be awarded to the winners and runners-up of the various events, and possession of the S.A.E. Cup for one year will be given the winner of the Championship Flight. A Ladies' Golf Tournament is also being planned by a committee headed by Mrs. D. E. Gamble.

Field Day, under the expert tutelage of S. S. Dickey of Cleveland, is becoming a popular institution at S.A.E. Summer Meetings. This will be the third year that such an event has been held during the Summer Meeting. Per-

want to miss. Besides the usual events for the participation of the members and some unusual ones too, the Carnival will include diving exhibitions by two of New York's most graceful mermaids.

Dancing, of course, will be featured on the Summer Meeting entertainment program and will take place every night just after the adjournment of the evening session. The Grand Ball will hold the spotlight on the evening of Thursday, June 18, the next to the last day of the meeting. Bridge will no doubt be as popular as ever with the ladies and, although no organized tournament will be held, those who wish to do so can make up their own parties. Arrangements for bridge will be taken care of by Mrs. Brede, of the S.A.E. staff.

One of the most attractive features to enliven the Summer Meeting will be the *Daily SAE*, a newsy paper, to be published this year through the courtesy of the B. F. Goodrich Rubber Co. The Goodrich company will have a capable staff on hand to get out this miniature but quite complete paper, which will be a conspicuous asset to breakfast tables at The Greenbrier from June 14 to 19.

Pittsburgh in the Industry

The City's Contributions Memorialized in a Joint Meeting of the Pittsburgh Section and the Chamber of Commerce

PAID ATTENDANCE of more than 200 was tangible evidence of the interest in the joint meeting on April 9 of the Pittsburgh Section of the Society and the Automotive Council of the Pittsburgh Chamber of Commerce. The meeting was a fitting climax to the successful exhibition of "made in Pittsburgh" automobile and aeronautic products which had been held in the Chamber of Commerce building during the preceding week. Musical entertainment was furnished by an orchestra and the Red Arrow Quartet, the goodwill representatives of the Pennsylvania Railroad.

Greater Pittsburgh, a magazine issued by the Chamber of Commerce, devoted more than seven pages to the exhibit and the meeting, featuring brief articles by officers of the Society, including Vincent Bendix, President; Arthur Boor, Chairman of the Standards Committee; B. B. Bachman, Chairman of the Research Committee; J. A. C. Warner, General Manager, and Murray Fahnestock, Treasurer of the Pittsburgh Section. Mr. Fahnestock also gave a ten-minute radio talk on Station KDKA, Friday, April 10.

President James Rae, of the Chamber of Commerce, extended a welcome to the members of the automotive industry. Then C. A. Rehtmyer, chairman of the Automotive Council of the Chamber, briefly explained that the purpose of the meeting was to show the variety and magnitude of Pittsburgh's participation in the automobile and aeronautic industries. He also welcomed Chairman E. W. Jahn and other members of the Motor Transportation Committee of the National Electric Light Association, who attended the meeting as guests of the Pittsburgh Section of the Society.

Frederick K. Glynn, Vice-President of the Society representing transportation and maintenance engineering, said that he knew long before he arrived in the city that the meeting would be a success, because "those persistent Pittsburghers" had sent him a reminder of some kind every few days, although only one invitation had been necessary to secure his attendance. Frank J. Lanahan, of the Fort Pitt Malleable Iron Co., acted as toastmaster. He recalled the lines "Make me a boy again just for tonight" and said that, if that could happen, the S.A.E. meeting would not be possible, because the automotive industry has grown up in the short time since those at the meeting had been boys.

John M. Orr, Chairman of the Section, expressed the thanks of the Society for the cooperation of the Chamber of Commerce, and General Manager Warner made some remarks to the effect that the modern engineer is interested not only in the "slip-stick" and technical results but in correlating the technical facts with business conditions. The Pittsburgh meeting, he said, is typical of the present policy of the Society to link the technical with the commercial to obtain practical results.

Steel, They Say, Comes from Pittsburgh

Several Pittsburgh executives participated in a symposium which recounted the contributions of Pittsburgh to the automotive industry. A representative of the steel industry, in the person of W. B. Todd, manager of sales of the Jones & Laughlin Steel Corp., appropriately came first. He said that in 1930 the automotive industry consumed 60 per cent of the strip steel, 39 per cent of the sheet steel, 29 per cent of the hot and cold-finished bars, 18 per cent of the rolled steel and 59 per cent of the malleable iron, and that the consumption of rolled steel is growing rapidly with the advent of corrosion-resisting and stainless steels. Mr. Todd also spoke of the contributions of the city in plate glass, aluminum, and products of coal and oil.

Aluminum was further represented by H. B. Churchill, chief chemist of the Aluminum Co. of America, who gave an interesting talk on Aluminum Transportation. Economical utilization of energy is said to be the fundamental problem of the world today. The success of the steel industry is not measured in tons of steel but in the way in which the steel enables men and industry to develop and utilize energy. Recalling the relationship of mass, velocity and kinetic energy, Mr. Churchill remarked that the Stone Age was characterized by little kinetic energy and much mass, so things did not move very rapidly. The discovery and use of lighter materials is an important factor in increasing speed.

A Lusty Infant Industry

Becoming available to industry only about 40 years ago, aluminum is now surpassed in tonnage only by iron, copper, lead and zinc, all of which have been known for ages, and iron is the only metal produced at any time during the 19th century in larger quantities than the 1929 tonnage of aluminum. Geochemists estimate that 8 per cent

of the earth's crust is aluminum, 4 per cent is iron and 0.01 per cent is copper, while zinc and lead exist in even smaller quantities. It is not to be anticipated that aluminum will soon be produced in quantities equal to that of iron, because of the difficulties attendant upon its extraction.

The chief advantage of aluminum in motor transportation is its saving in weight. Motorcoaches cost about as much as street-cars and must be depreciated entirely in four or five years, but they carry only about one-half as many passengers. By utilizing aluminum, they can be made one or two tons lighter and more flexible, with freedom from rust which impairs strength and makes repainting necessary. Aluminum bodies make possible an increase in the pay-load of motor-trucks, especially in States where the total weight of the loaded vehicle is limited; and aluminum in parts of passenger-cars, such as axle housings, torque members, front axles, brake shoes and wheels, makes possible great reduction in unsprung weight. Aluminum-alloy pistons, connecting-rods, cylinder-heads and other parts were also touched upon by Mr. Churchill.

Aviation affords to aluminum its first opportunity to pioneer in its own right. As the railroads stimulated the development of iron and steel and the electrical industry was built around copper, so aviation will depend upon aluminum.

Conrad Wins Honors for Westinghouse

Westinghouse and the Automotive Industry was the subject of a talk by S. M. Kintner, assistant vice-president of the Westinghouse Electric & Mfg. Co. Frank Conrad, who participated in the early electrical activities of the Standards Committee of the Society, applied an engine-driven dynamo and carbon-filament lamps to an automobile in 1906. This experience pioneered the manufacture by the company of the starters and generators for hundreds of thousands of motor-cars.

Micarta timing gears represent another important Westinghouse contribution. The present contributions of the company to the automotive industry are chiefly electric-light bulbs and manufacturing equipment, the latter including alternating-current motors and generators, which were pioneered by Westinghouse, electric-welding equipment and electric furnaces for heat-treating.

It was Mr. Conrad, also, who experi-

mented with the radio telephone at his own home and sent out musical programs, usually from phonograph records, which encouraged the first sales of radio receiving sets in Pittsburgh and led to the establishment of Station KDKA, said to be the pioneer broadcasting station of the world. This in turn has made manufacturers of tooth paste and cigarettes into ardent advocates of the dramatic and musical arts.

After broadcasting had become established, Mr. Conrad discovered the value of short waves for long-distance transmission by listening to the harmonics of local and distant stations. He was recently awarded the Edison Medal for this contribution of his to the radio art.

Forerunners of Aviation and Radio

Other basic contributions to the automotive industry that have come out of Pittsburgh include the classical experiments of Dr. S. P. Langley, made at the Allegheny Observatory, of which

he was director, that resulted in his statement of many of the fundamental laws of aerodynamics and in his construction later, while director of the Smithsonian Institution, of an airplane which finally was flown successfully by Glenn Curtiss.

A more remote source of radio is found in the experiments of R. O. Fessenden, who in the last '90s was a professor at W.U.P., now the University of Pittsburgh. These turned the trend of wireless development from the intermittent wave of Marconi to the continuous wave of the radio telephone.

Mr. Kintner concluded the meeting with a demonstration of equipment, some of which is under development for the future. This included an automatic traffic light, controlled by an "electric eye," a stroboscope for studying the action of rapidly moving mechanism and an automatic switch for turning on the flood-lights of a landing-field, actuated by a sound produced on or by an approaching airplane.

liquid fuel can be burned without flame, and the heat is so intense and the fuel burns so rapidly that the carbon is entirely consumed and carbon dioxide, with no monoxide, is formed."

Regarding carbonization in the engine, the speaker declared that 99.4 of the carbon comes from the gasoline, not from the lubricating oil. "This comes from the unburned C in the gasoline," he said. "Why not burn that so that no C will be deposited? To do this, all we need is flameless combustion developed to practical usage. For this purpose the cylinders need the correct ratio of gasoline and air so they will burn completely, leaving no free C in the cylinder."

To ascertain how complete is the combustion, the end or exhaust gases are measured. Then adjustment is made at the front or feed end. "If we are right at the last end, we are right at the start and on the inside," the professor continued. He predicted that flameless combustion will be the outstanding development of the future in automotive engineering.

Thermal efficiency gains through increasing the compression ratio in ordinary engines up to 7:1 would be very great, he said. To accomplish this, detonation must be fought, and overcoming this without the use of dopes in gasolines, but on a straight-run gasoline, would mean a saving of at least \$2,000,000 in the Country's monthly gasoline bill. Difficulties encountered in fighting detonation were pointed out. The metal dopes now used, it was explained, scatter metal particles in the combustion-chamber so that flames start at many points, for quick and intense burning, eliminating the flame wave which causes the detonation. The field is still wide open and full of promise for the reduction of detonation at higher compression-ratios by other means, with a 10 to 20-per cent more efficient engine the goal, he maintained.

Professor Baender, who is a student of the Diesel engine, predicted future automotive engineering development along the line of the Diesel injection principle but retention of the spark-plug and use of gasoline.

Secondary-Flame Phenomenon

Generation of a secondary flame, through the exhaust valve, which causes once-burned O and C to reunite after "dancing about," is a troublesome condition that is often noted. This results from dissociation and is one reason for low efficiency of engines, because of this burning of the fuel a second time in the exhaust manifold. The remedy is to add something to the fuel "to make it stay burned." In the meantime, this is one of the outstanding problems in developing higher engine-efficiency. This "second burning" was explained by the statement that, "when
(Continued on p. 589)

Flameless Combustion Sought

Professor Baender Makes Interesting Predictions at Northwest Section Meeting

THE REGULAR April meeting of the Northwest Section was held Friday evening, April 10, at the New Washington Hotel in Seattle, with the largest attendance of the year attracted to the meeting by the announcement that Prof. Fred G. Baender, head of the mechanical engineering department of Oregon State College, would talk on his long-anticipated subject of Flame.

The chemistry, properties and nature of flame were discussed, first in general, and then as applied to internal-combustion-engine cylinders. Detonation, preignition and some recent thoughts on dissociation and its evil effects on engine efficiency were also considered.

Chairman Gilmore announced that the next meeting of the Section would be on May 8, and Charles Finn, in a short talk, welcomed those present who are not members.

Professor Baender told elementary facts concerning the behavior and chemistry of combustion and explained various forms of oxidation, all coming under the head of burning, from the slow rusting of iron to the high speed of an explosion. Molecular action, the proton and electron theory of elements, and the chemical reactions of burning were carefully explained.

Automobile engineers are not interested in the creation of heat for the sake of heat, but merely to turn the heat into work, said the speaker. Cooling systems had to be created to reduce the effect of the heat itself. The

important place of the nitrogen in the air, in relation to combustion in engine cylinders, was explained as being that of a chaperone, while the hydrocarbons and oxygen do their work of expanding to cause the power stroke.

Pocket-Size House-Heating Furnace

Possible development of a furnace no larger than a water glass was predicted by Professor Baender, who operated such a furnace in Indiana a few years ago, heating with oil a seven-room house during zero weather at one-third of the fuel cost of the ordinary furnace. This was an intriguing sidelight of the lecture, and, in the questioning after the address, much interest was shown in its commercial possibilities. The tiny furnace was surrounded by a water-jacket, and hot-water pipes carried the heat all over the house to the radiators. Granules of the size of peas filled the tiny-tube furnace, and flameless, very intense combustion heated the granules to a red heat, when the oil was shot in and vaporized. A white dazzling heat was formed, with no flame. The trouble with this furnace was to get granules that would not melt in a short time and cause trouble. Further experimentation along the line of the "tiny furnace" is now being carried on at Oregon State College.

"We are entering a new field of combustion engineering," said Professor Baender, "and this is in relation to burning oil without flame. We now have apparatus for this purpose. A

Chronicle and Comment

Six Fine Days at White Sulphur CARAVANS are already forming for the great movement of engineers to White Sulphur Springs in June. Just before June 14, to be exact, the astonished natives of West Virginia will become aware of the fact that something momentous is happening in their favorite State. Automobiles, aircraft, special trains will be bringing a host of the automotive fraternity to one of the most attractive resorts in this Country.

We are told that the Pittsburgh, Washington and Baltimore Sections are organizing motor caravans and that a large number of our members intend to drive down individually. Special trains will run from the East and Middle West.

Officially opening on Sunday, the 14th, the meeting will run for six days. It will be difficult to crowd into the meeting period all the important work at hand. However, Chairman Norman G. Shidle and his Meetings Committee have made special arrangements this year to avoid conflict among the numerous important features of the well balanced program.

Various Activities have come through earlier than is customary with a most excellent array of talent for the sessions. Special technical features are already "on ice" and will be announced in detail soon. Unusual efforts are being directed toward making this engineering gathering break all records for interest and value.

Accommodations at White Sulphur, with the hotel addition, are adequate and the best that can be had.

Current Aircraft Standardization COINCIDENT with the 19th National Aeronautic Meeting of the Society in Detroit, important progress is being made in standardization affecting both aircraft and aircraft engines. Within the last two years, much has been accomplished in the standardization of materials such as extruded structural shapes, rivets, mountings for aeronautical instruments and so on. The Aircraft Division of the Standards Committee is now formulating complete standards for both streamline and circular structural tubing among other subjects in progress. The Ball and Roller-Bearings Division of the Standards Committee is also developing a standard for a narrow-type light series of annular ball-bearings, in the use of which a saving in weight is a prime consideration. More complete information is given regarding the standardization projects in the Standardization Progress Section of this issue of THE JOURNAL.

The S.A.E. in International Standardization THE international contacts established with the Allies during the World War have been continued since with much discussion of international standards and some worthy accomplishments in certain industries.

The S.A.E. has been a leader in automotive standardization from the industry's very beginning. With the inroads which the American automobile has made in foreign markets and the predominant position which is predicted for the United States in supplying the world with motor-driven transportation, is it not logical

that the Society should aggressively participate in the international parts standardization which is now progressing through the channels of the International Standards Association but without the active participation of American representatives through the S.A.E.?

What can be accomplished is well illustrated by the leading position which the Cooperative Fuel-Research Steering Committee has taken in interesting other countries, notably Great Britain and Germany, not only in the establishment of uniform practice in methods of measuring detonation but in what is even more significant than general acceptance of a universal method, international cooperation in the fundamental research which must form the basis for any permanently satisfactory procedure. Probably there has never heretofore been more definite and whole-hearted cooperation in research looking toward international standardization than is manifest in the present undertaking in which the Society has contributed to the best of its ability.

Diesel-Engine Testing Forms Available THE standard testing forms for Diesel engines that were developed by the Diesel-Engine Division of the Standards Committee last year and approved by the Society in January, are now available from stock at the office of the Society. The set consists of seven sheets; General Rules and Directions—Sheet A; Specifications—Sheet B; Log Sheet—C; and four curve sheets, of which No. 1 is for low and medium-speed low-power engines; No. 2 for low and medium-speed medium-power engines; No. 3 for low and medium-speed high-power engines, and No. 4 a blank sheet for miscellaneous speed and power engines.

These testing forms will prove of great value to the Diesel-engine manufacturers and users by enabling them to completely standardize the records of the performance characteristics of their engines and to at any time make direct comparison with any other engines without having to transcribe or replot these data. The gasoline-engine manufacturers and users have found that the gasoline-engine testing forms adopted by the Society 14 years ago have been of great value to them. The forms for both types of engine may be obtained in single sets or in quantity lots from the Society at a nominal cost.

Save Your Journals As announced in the April issue, our Council has directed the suspension of TRANSACTIONS; consequently there will be no duplication of the material printed in the S.A.E. JOURNAL. Obviously, those who wish to keep a complete file of THE JOURNAL material should save their current copies and also those numbers that have been published since the last issue of TRANSACTIONS.

The Aeronautic Meeting IN some detail the story of the 19th National Aeronautic Meeting of the Society is told in this issue of THE JOURNAL. Attention is specifically directed to the account of events that took place at this very important and successful gathering of leading men in the various aeronautic fields of endeavor.

Commercial Flight-Testing

19th National Aeronautic Meeting Paper

By Lieut.-Com. E. W. Rounds, U.S.N.R.¹

WHILE complete performance figures for airplanes are generally available, these are usually either estimated or calculated. Prospective purchasers seldom have the necessary equipment or personnel to check the statements made in manufacturers' advertisements and no impartial commercial establishment is available to supervise or conduct performance tests or to certify to the results obtained. The author lists the various items of airplane performance which are valuable to the manufacturer for advertising purposes and which can be reduced to a basis that permits comparison with other data obtained in a similar

manner and outlines in some detail the methods for determining these items. Numerous illustrations supplement the text, and tables of data obtained in tests are included.

The author regards the Aeronautical Chamber of Commerce of America, Inc., as being the organization best fitted to issue certificates of performance, since the Aeronautics Branch of the Department of Commerce has apparently abandoned this work. Suggested regulations to guard against the approval of unreliable data when tests are not conducted nor supervised by the approving agency conclude the paper.

FLIGHT TESTING covers a wide range and can be interpreted to include anything, from a test flight of an airplane which has just had changes made in the setting of the vertical fin, to flights made to determine major changes in the design of the airplane or securing data from which its full-flight performance can be derived. This paper covers methods of flight testing having to do with the measurement of those performance characteristics that are of interest to the commercial operator but are not now determined except in special cases. From a comparison of performance figures obtained as set forth herein, logical and fair conclusions can be drawn as to the relative desirability of each type of airplane for the use contemplated.

Statistics are available in the various automotive publications covering both automobiles and airplanes. In the case of the former, performance is seldom mentioned, while for the latter complete performance figures usually are given. Checking the speed, acceleration or relative hill-climbing abilities of several motor-cars is comparatively simple for the prospective purchaser, but he seldom has available the equipment and personnel necessary to obtain the desired data on various airplanes.

The impossibility of judging relative merits of automobiles from the statements appearing in advertisements must be evident to all. That airplane manufacturers are any less optimistic or enthusiastic is hardly to be assumed. However, in a number of cases, where performance measurements have been made by competent agencies, the figures have appeared correctly in the advertising literature. This leads to the conclusion that, if an impartial performance-testing agency were available, the manufacturers producing a really good article would be quick to avail themselves of its services.

Believing that the publication of correct performance figures would benefit the aeronautic industry as a whole and also the general public, the Aeronautics Branch of the Department of Commerce, in Aeronautics Bulletin No. 7-A, issued in July, 1929, included a section cover-

ing the requirements necessary for approval of performance data obtained from flight tests. The object of this section was to encourage airplane manufacturers in obtaining reliable performance figures concerning their product, both for their private use and for advertising purposes. Much to the surprise of those interested in the subject, the manufacturers failed to take advantage of the opportunity offered for approval of performance obtained by an impartial agency and only one set of data was submitted for approval. These data were obtained from tests on Spartan airplane Model C3-225 which I conducted at Tulsa, Okla., in January, 1930. While the data and results submitted were approved as an individual case, the Department of Commerce suspended the section of the Bulletin covering such approval and to date has made public no announcement that would indicate the probability of its reinstatement.

Competent Commercial Organization Needed

At present no impartial commercial establishment in a position to supervise or conduct performance tests or to certify to results obtained exists. The facilities of the Army, Navy and National Advisory Committee for Aeronautics are not available to the aeronautic industry in general. Opportunity, therefore, appears to exist for a competent commercial organization in the performance-testing field. A number of proposals have been made in the past to form organizations whose business would be to determine the performance of airplanes, and several attempts at commercial flight-testing have actually been made. The airplane manufacturers generally, while admitting the desirability of performance testing, have, with one or two exceptions, shown only interest, and their own pilots have carried out such testing as has been done. Several reasons were responsible for this, notably the following:

- (1) Ignorance along aeronautic lines on the part of the general public, so that intelligent comparison of a manufacturer's claims and products could not be made even if performance data were available

¹ M.S.A.E.—Aeronautic engineer, Naval Air Station, Anacostia, D. C.



Three-Quarter Front View



Three-Quarter Rear View

FIG. 1—PHOTOGRAPHS SHOWING ALL PARTS OF AN AIRPLANE EXPOSED TO THE RELATIVE WIND PRODUCED BY FORWARD MOTION

- (2) The great boom experienced in aviation, which resulted in the sale of all types of airplane with no real competition
- (3) Resulting from (2), the lack of any real need for accurate performance figures except as involved in Army and Navy requirements
- (4) The lack of competent testing agencies available to the manufacturer
- (5) The unsatisfactory results of tests attempted by certain agencies, due to lack of experience in flight testing, and consequent inability to supervise the tests properly
- (6) The absence of a generally accepted method of reducing observed data to a suitable basis of comparison

These objections now either do not exist or can be met without serious difficulty. The public is rapidly becoming informed on aeronautic subjects and will soon be in a position to make use of statistics; the boom in aviation is surely over, making competition keener; equipment and personnel are becoming available for carrying out performance tests; and satisfactory methods of reducing observed data to standard conditions are being evolved.

Items of performance which are of value and can be measured with satisfactory accuracy for given conditions are:

- (1) Minimum speed without power
- (2) Maximum horizontal speeds at altitudes up to 75 per cent of the service ceiling
- (3) Maximum rates of climb at altitudes within the range of the airplane
- (4) Time of climb to altitudes within the range of the airplane
- (5) Service ceiling, where rate of climb is 100 ft. per min.

TABLE 1—EFFECT OF CHANGES IN WEIGHT AND POWER ON AIRPLANE PERFORMANCE

	Changes in Weight				Changes in Power	
	High Performance		Low Performance		Original Data	Change, Per Cent
Weight, lb.	Original Data	Change, Per Cent ^a	Original Data	Change, Per Cent ^a	Original Data	Change, Per Cent
Power, hp.	2,660	-8.9	7,315	-12.5	7,359	1.3
Maximum Speed, m.p.h.	157.6	No change	113.2	2.2	544	9.0
Landing Speed, m.p.h.	57.0	-5.0	58.0	-6.0	...	...
Initial Climb, ft. per min.	1,830	6.5	460	43.5	560	16.0
Service Ceiling, ft.	21,000	8.6	10,150	44.8	10,400	14.4

^a A minus sign preceding the figures indicates a decrease.

In certain cases other characteristics can be measured with reasonable accuracy, but these are difficult to place on a basis of comparison with other data. To make comparisons logical, the conditions under which the airplanes are tested must be known in detail. The weight and power available are perhaps the major factors but streamlining and the type of external equipment carried, such as cowlings, windshields or cockpit covers, landing-gear and the like, also influence the performance. Specifically, the following particulars concerning the airplane when tested must be available:

- (1) *Weight Data.*—These include the total gross load carried, center-of-gravity location, disposable or payload, fixed equipment, fuel and oil, and number in the crew. This information should be detailed.
- (2) *Powerplant Data.*—These include type of engine; carburetor specifications; compression ratio; supercharging conditions, if a supercharger is used; position of heat control; revolutions per minute at maximum horizontal speed at the critical altitude; fuel and oil used; and propeller design and diameter, with pitch or blade-setting.
- (3) *External Equipment.*—This is best shown by photographs sufficient in number to show all parts of the airplane exposed to the relative wind produced by the forward motion of the airplane. In most cases, two photographs, a three-quarter front view from one side and a three-quarter rear view from the other, as in Fig. 1, will show all external equipment.

Changes in weight, power and equipment affect airplanes to various extents depending on many factors, including fineness, wing loading, power loading and initial performance. In general, high-performance airplanes will show less proportionate change in performance for a given percentage change in weight than will a low-performance machine. The results of flight tests presented in Table 1 illustrate this, although the changes in weight are not equal in percentage. These changes in performance were due to changes in weight alone, the powerplants being the same for both conditions of loading for each airplane. An example of a change in performance due almost entirely to a change in power is also given.

Changes in external equipment or cowlings affect performance in different ways. The addition to an engine ring-cowl may raise the high speed from 5 to 10 per cent, while an increase in size of a windshield may noticeably decrease the speed. In one case the addition

of wheel fairing increased the high speed approximately 3 m.p.h., while in the case of another airplane no increase was found.

Weighing the Airplane

The best method to be used in weighing a given airplane depends on its type and the facilities available. In most cases the longitudinal position of the center of gravity can be obtained with little more work than is involved in securing weight data alone. It should therefore be determined, at least for the full-load condition. To cover all cases that may arise is impossible, and, since probably nine-tenths of the airplanes can be weighed on three scales, this method will be covered in detail, assuming a landplane with two main landing-wheels and a tail-wheel but without hoisting sling. The articles necessary for correct determination of the weight and the location of the center of gravity are: three scales of adequate capacity, blocks and jacks for positioning the airplane, inclined planes, block and tackle, plumb-bobs, cord, steel tape, straight-edges, carpenters' level, machinists' level protractor and forms for recording data. This equipment is shown in the top view of Fig. 2.

Empty weight should be determined first. The airplane is prepared for weighing by removing all articles that are not part of the structure or fixed equipment. Fuel and oil are drained from the tanks, but cooling water,

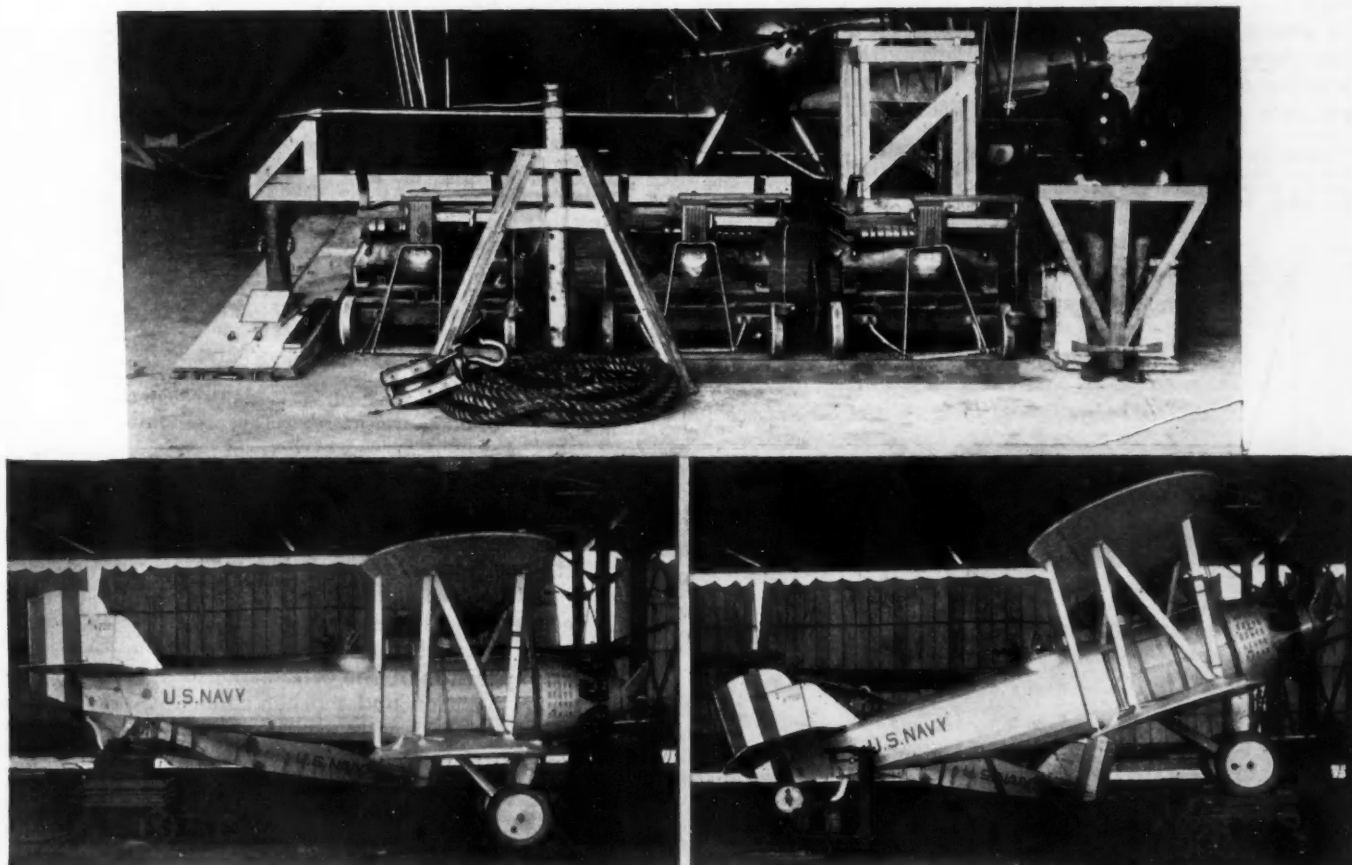
if used, is usually allowed to remain in the system as part of the empty weight. Often certain articles of disposable load will be installed in such a way as to make removal difficult. In this case their weights should be determined or estimated and subtracted later from the total-weight readings.

The location chosen for the weighing should be protected against the wind, and the support for the scales should be solid to prevent any change of level under load. When ready, the scales and inclined planes are placed in position ahead of the two main landing-wheels. If the airplane is light, possibly a number of men can push it on the scales; if heavy, block and tackle may be necessary. Before placing the airplane on the scales, the latter should be balanced and the zero correction, if any, determined.

In actually moving the airplane up the inclined planes and on the scales, care should be used to eliminate any chance of damage to the airplane. The scales should be blocked or their wheels removed, while chocks should be used to prevent the airplane from over-running the scale platform or sliding back down the inclined plane. After the main landing-gear wheels have been blocked on the scale platforms, the tail may be placed on a third scale. Lifting can be done manually, with jacks or by portable cranes or hoists.

Assuming that the determination of the location of the center of gravity is desired only for full load, level-

The Three Scales, Blocks, Jacks, Inclined Planes, Block and Tackle, Plumb-Bobs, Cord, Steel Tape, Carpenters' Level, Straight-Edge, Incidence Board and Machinists' Level Protractor, All of Which Are Required To Determine the Weight and the Location of the Center of Gravity



Weighing an Airplane with Its Longitudinal Axis Horizontal Determining the Weight of an Airplane in the Landing Attitude
FIG. 2—AIRPLANE-WEIGHING EQUIPMENT ASSEMBLED AND IN USE

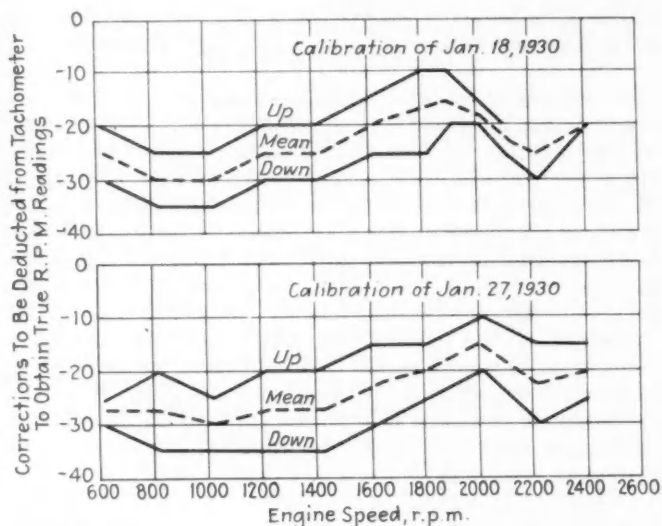


FIG. 5—CALIBRATIONS OF A TACHOMETER MADE BEFORE AND AFTER A SET OF PERFORMANCE TRIALS

While the Corrections Are Considerable, the Maximum Difference between the Means at Any Speed Is Less than 5 R.P.M. A Reasonable Assumption Is That the Accuracy Did Not Change between the Two Calibrations

for a normal airplane is in the range between 25 and 35 per cent of the mean aerodynamic chord. If the center of gravity lies outside these limits the airplane is likely to prove unstable or uncontrollable in certain conditions of flight.

Calibration of Instruments

Before commencing flight tests, all instruments that are to be used should be calibrated and their installation checked to assure proper functioning. Certain instruments, such as barographs, air thermometers and air-speed indicators or recorders, are used directly in determining the performance characteristics of the airplane, while others, such as fuel or oil-pressure gages, power-plant thermometers and engine-revolution indicators, are just as necessary in showing how the airplane and powerplant are operating.

Methods used in the calibration of instruments are described elsewhere³, but brief comment here may be of interest. An instrument-testing laboratory should be equipped with the following apparatus for routine calibration:

- (1) Bell jar, mercurial altitude barometer and operating accessories for calibration of barographs, altimeters and suction gages
- (2) Liquid manometer for calibration of air-speed indicators
- (3) Tachometer tester for calibration of engine-revolution indicators
- (4) Standard thermometers
- (5) Dead-weight tester for calibration of pressure gages
- (6) Water bath with heat control for calibration of thermometers
- (7) Potentiometer and necessary tables for calibration of thermocouples
- (8) Stop-watches, counters, data forms and miscellaneous supplies
- (9) File for preservation of calibration records

³ See Aircraft Instruments, by H. N. Eaton, K. H. Beij and W. G. Brombacher; Flight-Test Instruments, by J. B. Peterson and E. W. Rounds, published in the S.A.E. JOURNAL, March, 1930, p. 313; and University of Michigan Engineering Research Bulletin No. 9.

Correct standardization of testing equipment is of the utmost importance and can be obtained at a nominal cost through the Bureau of Standards. Calibrations of stop-watches and special instruments can also be secured by application to the same agency. In addition to the foregoing equipment, means should be available for checking and setting propellers to the correct blade angle.

Fig. 4 shows the calibration of a well seasoned barograph. These calibrations are of particular interest, as they were made to show that between the dates noted on the chart no change in the characteristics of the instrument had occurred. They show further that, for changes of instrument temperature between +20 and -15 deg. cent. (68 and 5 deg. fahr.), no correction to the calibration need be considered. A very slight shift may occur over periods of 3 or 4 months and a good practice is to calibrate barographs at least once a month when in continuous use and before and after any special tests. Constant watchfulness to detect and interpret peculiarities sometimes found in the records is necessary.

In Fig. 5 are plotted the results of two calibrations made on a tachometer before and after a set of performance trials. While the corrections are considerable, the maximum difference between the means at any speed is less than 5 r.p.m., and we can reasonably assume that the calibration has not changed between the dates given. Detection in flight of variations of less than 10 r.p.m. is extremely difficult. In applying corrections to tachometer readings the mean of the up and

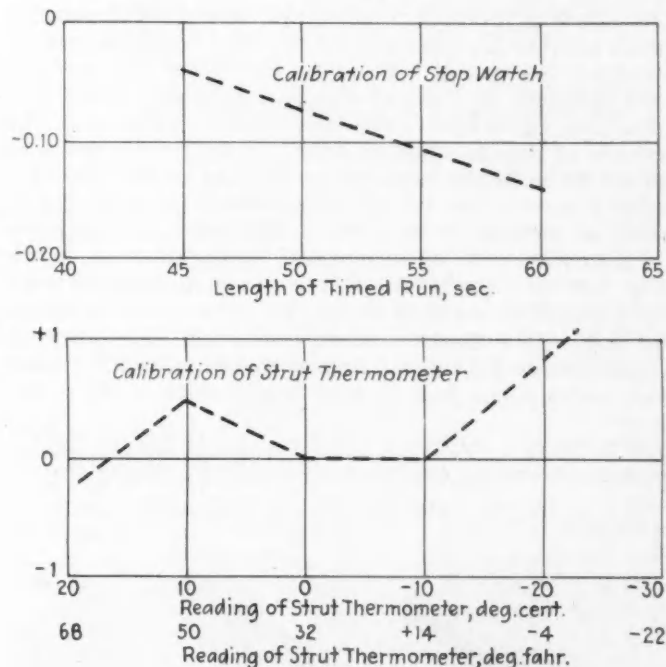


FIG. 6—STOP-WATCH AND STRUT-THERMOMETER CALIBRATION-CURVES

As Only the Corrections to the Timing of Maximum Speed Are Important, the Range Covered in Calibrating the Stop-Watch Is Small

down calibrations is used, since determining whether a given indication in flight has been reached from a lower or higher engine-speed is usually impossible.

In Fig. 6 corrections are shown to be applied to the readings of the stop-watch and strut thermometer that were used in the trials previously mentioned. Only the

corrections to the timing of maximum speed were important, which accounts for the small range covered for the stop-watch.

Calibration of the Air-Speed Indicator

Many devices have been used to indicate the speed of an airplane through the air. The most satisfactory for use in flight testing is the pitot-static type, examples of which are shown in Fig. 7. Theory covering the functioning of the pitot-static tube can be found elsewhere⁴. It is sufficient to say that the differential pressure developed by the head is very closely proportional to the air density ρ and the square of the air-speed v . This relation is used in determining true air-speeds from the readings of an indicator or recorder.

Locating the pitot-static head in such a position as to be unaffected by interference from the airplane structure is difficult if not impossible. For this reason calibration of the indicator and recorder must be made with the instruments installed in the airplane. One exception exists in the suspended-head type, which can be calibrated in the wind-tunnel. The calibration of an air-speed indicator consists in obtaining comparisons, at several speeds covering the range of the airplane, between the indicated speed or reading and that which is theoretically correct for the conditions. The latter is called true indicated speed⁵ and is plotted against actual readings in a calibration curve, as shown in Fig. 8.

Various methods are available for making a calibration for an airplane under test. The simplest and most satisfactory procedure combines flying in formation with another airplane and timing runs over a measured course. No special installation difficulties are involved and sufficient accuracy is usually attainable. Using this practice, calibration runs are usually made over the course at speeds ranging from the maximum down to about 20 or 30 m.p.h. above the stalling speed. Calibration at speeds below this, which should include one as close as possible to stalling, is made at a safe altitude in formation with an airplane of lower minimum speed. The air-speed indicators of the two airplanes are read simultaneously while in formation. The slower can then be flown over the measured course at the indicated speed obtained in formation with the airplane under test without the hazard that would exist if near the

⁴See National Advisory Committee for Aeronautics Reports Nos. 2 and 110 and Technical Memorandum No. 303; also British Advisory Committee for Aeronautics Reports and Memoranda No. 71.

⁵See National Advisory Committee for Aeronautics Report No. 216, part 3.

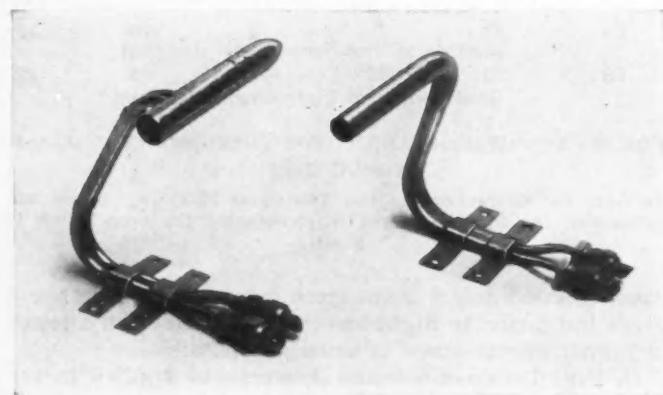


FIG. 7—PITOT-STATIC TYPES OF AIR-SPEED INDICATOR

stall. The true indicated speeds for corresponding observed speeds will be the same for both airplanes.

The observed data taken during an air-speed indicator calibration consist of times over the course, air-speed indicator readings, air temperature and pressure at the altitude of the runs and the number of revolutions per minute. Times are taken with a stop-watch or chronograph, the latter being mounted on a board which is strapped to the pilot's leg. A convenient type is shown in Fig. 9. The indicated air-speed and revolutions per minute are read from the meters in the cockpit. Air temperature must be measured outside the effect of the powerplant, which can most easily be done by a liquid-filled strut-thermometer or a distant-reading type, such as that shown in Fig. 10. The atmospheric pressure can be obtained either by using a barograph that is properly mounted in the airplane or

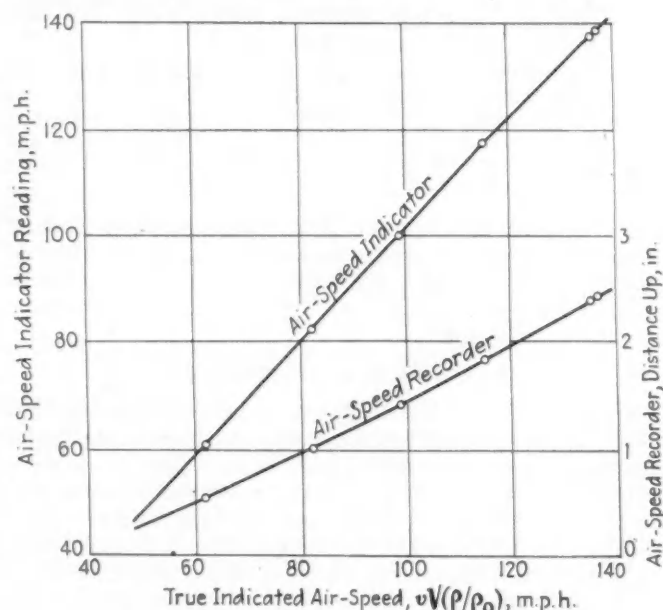


FIG. 8—AIR-SPEED INDICATOR AND RECORDER CALIBRATION-CURVES

from a ground aerological station with corrections applied for altitude difference, if any.

The reliability of an air-speed indicator calibration depends on the conditions under which the runs are made. Absolutely still air almost never is found and, to eliminate the effect of wind in the results, runs usually are made in pairs consisting of traverses of the course, one with and one against the wind at the same indicated speed. This assumes that the wind is blowing parallel to the course. No appreciable error results if calibrations are made with a cross-wind component that does not exceed 5 m.p.h. High winds, although parallel to the course, are likely to be gusty and to make estimation of the indicated air-speed difficult. The best results usually are obtained when the wind is parallel to the course and has a steady velocity of from 3 to 5 m.p.h.

Suggestions applying to calibration of the air-speed indicator or recorder are as follows:

- (1) Lay out the speed course parallel to the direction of the prevailing wind.
- (2) Use a course at least 2 miles in length.
- (3) Provide level approaches to each end of the course at least 2 miles in length.

TABLE 2—COMPUTATION OF AIR-SPEED INDICATOR AND RECORDER CALIBRATIONS

Time over Course, Sec.	Ground Speed, M.P.H.	Average Ground Speed, M.P.H.	True Indicated Air-Speed Reading, M.P.H.	Air-Speed Indicator Reading, M.P.H.	Air-Speed Recorder Distance Up, In.	Engine Speed, R.P.M.
<i>Jan. 22, 1930—2:00 to 2:45 p. m.</i>						
54.6	131.9					
56.6	127.2					
54.4	132.4	129.7	135.1	138	2.40	2,035
56.6	127.2					
63.9	112.7	110.1	114.9	118	1.82	1,780
67.0	107.4					
73.7	97.7	94.7	98.7	100	1.38	1,580
78.5	91.7					
88.0	81.8	79.0	82.3	82	0.98	1,395
94.5	76.2					
103.0	69.8	67.8	70.7	70	0.72	1,295
109.4	65.8					
<i>Jan. 23, 1930—10:15 to 10:45 a. m.</i>						
55.2	130.4					
55.4	130.0	130.3	135.9	138	2.42	2,040
55.2	130.4					
55.2	130.4	59.7	62.2	61	0.54	1,275
119.6	60.2					
121.6	59.2					

These calibration runs were made on a C3-225 Spartan airplane, No. NC708N, at Tulsa, Okla., by E. W. Rounds over a course 10,560 ft. long. The air temperature when both tests were made was -11 deg. cent. (12.2 deg. fahr.) and the value for $\sqrt{(\rho/\rho_0)}$ was 1.042. On Jan. 22, the air pressure was 29.57 in. of mercury and on Jan. 23 it was 29.56 in. of mercury.

- (4) If the course is laid out over the ground, the difference in altitude of the two ends should not be greater than 50 ft. in 2 miles.
- (5) Markers at each end of the course should be two in number and placed so that a line through them is perpendicular to the course.
- (6) Markers must be plainly visible and painted to stand out from the background so that no doubt will exist as to the instant of crossing the end of the course.
- (7) Air-speed indicator and recorder can be connected to the same lines with satisfactory results.
- (8) Check air-speed indicator installation for leaks before starting calibration.
- (9) The altitude flown should be such that the markers can be easily lined up.
- (10) Enter the course at the speed to be maintained throughout its length.

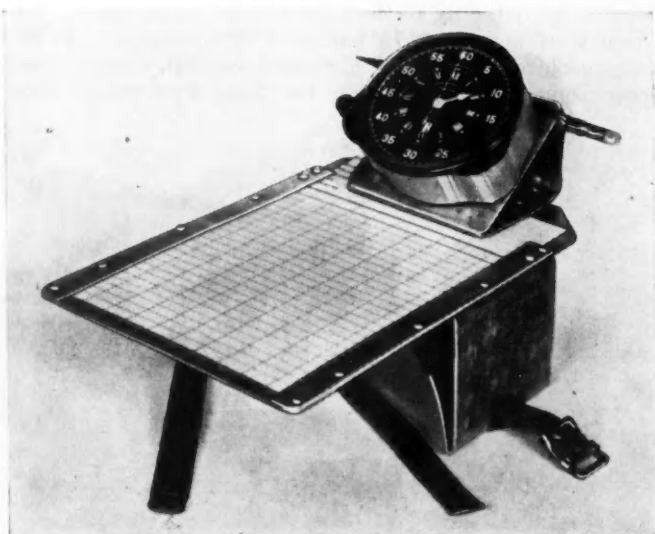


FIG. 9—STOP-WATCH, CLOCK AND BOARD FOR RECORDING PERFORMANCE-TEST DATA

As the Board Is Strapped to the Pilot's Leg, This Combination Provides a Very Convenient Means for Recording the Data

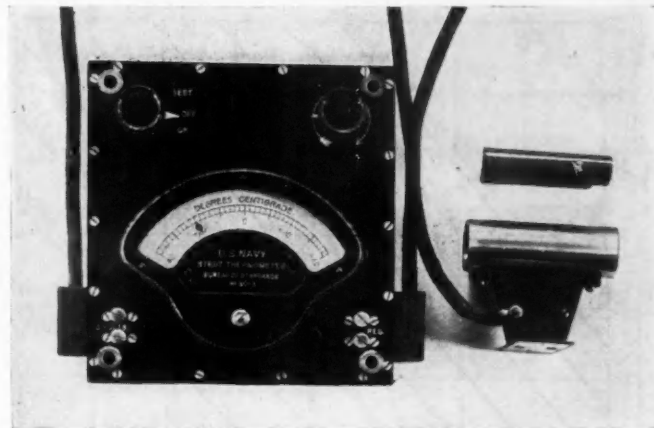


FIG. 10—A STRUT THERMOMETER OF THE ELECTRIC-RESISTANCE TYPE

As the Air-Temperature Reading Must Not Be Affected by the Powerplant, a Distant-Reading Type of Instrument Must Be Used

- (11) In calibration runs, maintaining constant air-speed is more important than constant altitude or revolutions per minute.
- (12) In calibration runs, keep the indicated air-speed constant by changing the throttle setting if necessary. Usually, with constant revolutions per minute the speed will be constant.
- (13) Obtain at least five points on all calibrations.
- (14) When calibrating in a cross wind, holding the thrust line parallel to the course and permitting the consequent drift will eliminate the effect of the cross wind.
- (15) Calibration should not be made with a gross load differing more than 15 per cent from that carried in tests.

Table 2 is an example of the calculations involved in obtaining the calibration curves of an air-speed indicator and recorder which are plotted in Fig. 8. The value of $\sqrt{(\rho/\rho_0)}$, the square root of the ratio of the density existing at time and altitude of runs to the standard density, can be obtained by calculation or read from a chart, such as is shown in Fig. 11. Fig. 12 illustrates the air-speed recorder used in this calibration.

Maximum Speed

An airplane equipped with a normal engine is usually assumed to attain its maximum level speed at standard sea-level. For this purpose standard sea-level is the altitude at which the barometric pressure is 760 mm. (29.92 in.) of mercury. While flying at standard sea-level is not always possible, sufficient accuracy for speeds correctly timed over a measured course will result if the barometric pressure is within 10 mm. (0.39 in.) of standard. The maximum speed of an airplane under any given condition can be measured in this manner to a precision of 0.2 per cent.

When supercharged engines are used or when speeds at great altitudes are desired, resort must be had to the air-speed indicator or recorder. The accuracy of speeds determined in this way is much less, the probable error amounting to at least 1 per cent. Due to this and also to the small change in maximum level speed with minor changes of altitude, the use of the theoretical method of deducing sea-level speed from the curve through true speeds at various altitudes is not warranted.

Before making the test for maximum speed the air-

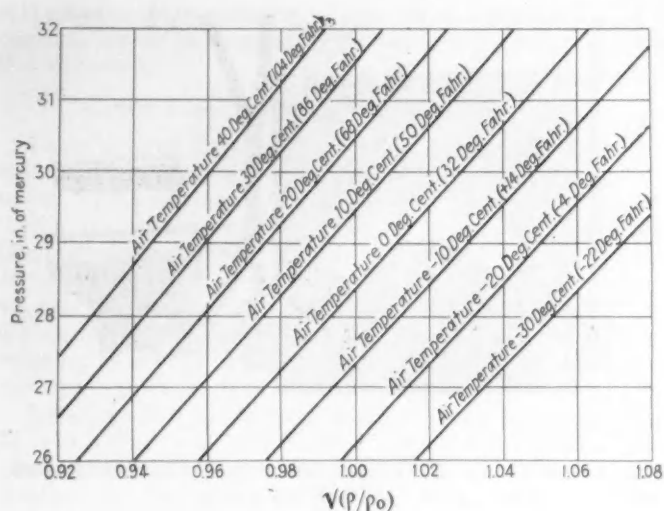


FIG. 11—CHART FOR CALIBRATING AIR-SPEED METERS

This Chart Shows the Variation in the Square Root of the Ratio of the Density Existing at the Time and Altitude of the Test Runs to the Standard Density, $\sqrt{(\rho/\rho_0)}$, with Temperature and Pressure

plane should be flown in level flight close to the ground, or at the critical altitude when supercharging is used, to be certain of the engine speed. The operation of the powerplant should be investigated to determine what combinations of heat control, mixture control and carburetor equipment will give the maximum number of engine revolutions per minute. If the engine does not turn at the required speed, the propeller setting should be changed to give the desired result. With direct drive an increase of 1 deg. in blade angle will decrease the engine speed about 60 or 70 r.p.m.

Maximum speed for a given engine-propeller combination may or may not be obtained at the desired revolutions per minute of the engine, depending on the propeller characteristics. To determine this, maximum-speed runs should be made at several propeller settings and a curve of air-speed against engine revolutions per minute or blade setting plotted. If maximum speed is obtained at less than the desired revolutions per minute of the engine, it indicates that the propeller is too large for the conditions. Contrary to the generally accepted theory that the best-climbing propeller does not give maximum speed, in every case where a comparison was possible the propeller setting that produced maximum speed also has been found to give the best climb-performance.

A propeller should be used which will give maximum speed at the desired maximum engine-speed. This number of revolutions per minute will normally be that given by the engine manufacturer for the particular type in question. The Department of Commerce allows an increase of not more than 5 per cent in the rated engine-speed, and it will usually be favorable to the airplane performance if advantage is taken of this.

Having determined the conditions under which maximum speed is to be measured, a time should be selected when the wind is in a direction parallel to the course and of low velocity. The ground speeds on at least six consecutive runs, three with and three against the wind, should be averaged to obtain the final speed.

In addition to the points previously listed in connection with the air-speed indicator calibration, the following should be noted:

- (1) The strut thermometer should be removed.
- (2) Care must be taken to enter the course at exactly maximum speed.
- (3) Maintain horizontal flight throughout all runs.
- (4) Avoid making runs in anything but smooth air.
- (5) Ignore runs that show variations of more than 10 r.p.m. from mean maximum engine-speed.
- (6) Make maximum-speed runs only when the powerplant is operating under normal conditions.
- (7) Make maximum-speed runs only when the relative humidity is less than 75 per cent.

Speeds at Altitudes

The foregoing applies only to the case of full-power runs made at ground level over a measured course. Equipment for timing speeds at altitudes has been designed and constructed but is too complicated and expensive for ordinary use. If supercharged engines become standard equipment, a commercial flight-testing organization may find that securing such facilities is desirable.

The greatest difficulty in connection with measuring maximum speeds at high altitudes is to determine whether the results are reliable. If the air were always still, the problem would be greatly simplified, as this would eliminate the up and down currents that are so difficult to detect. The importance of this can be seen when we realize that an upward motion of the air of 1 ft. per sec. will cause an increase of nearly 1 m.p.h. in the apparent speed of an airplane which under the same conditions in still air would be flying at the rate of 100 m.p.h.

Instruments are available which, under proper conditions, will indicate a constant-pressure level. The most important of these are the statoscope, the barograph and the altimeter. Variations of these are found in the rate-of-climb indicators, level-flight indicators and sensitive altimeters. By careful use of one or more of these instruments, very satisfactory results can be had in maintaining constant altitude.

The data needed in computing the speed of any altitude are the air-speed indicator reading, air temperature and air pressure. The revolutions per minute should be noted as a check on engine performance. Humidity of less than 75 per cent is assumed to have a negligible effect on the air-speed indicator and powerplant operation. Knowing the temperature and pres-

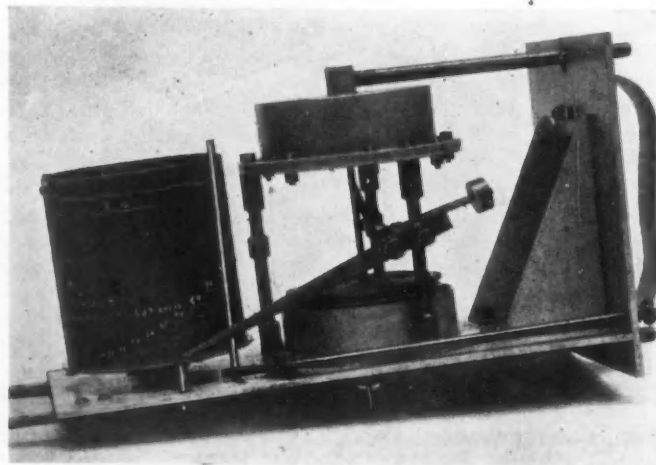


FIG. 12—AIR-SPEED RECORDER

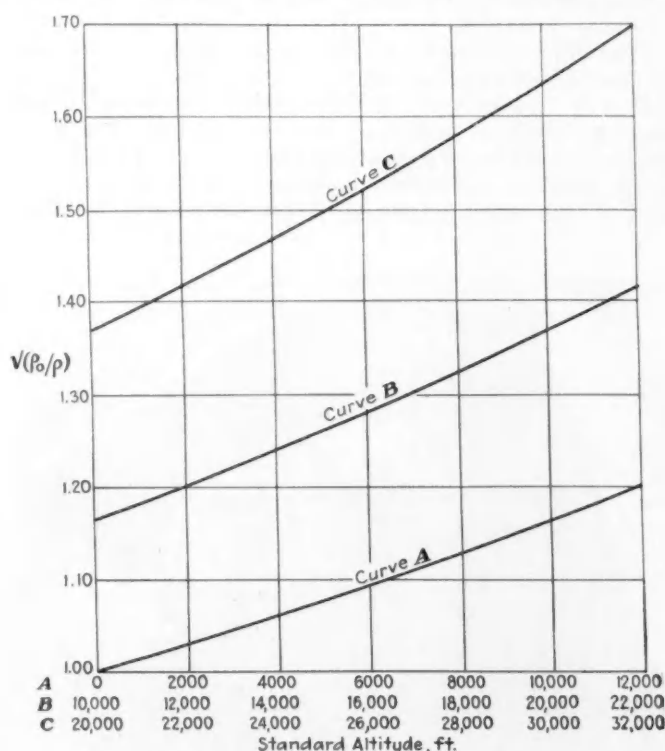
TABLE 3—CALCULATION OF SPEEDS AT ALTITUDE

Indicated Altitude, ft.	10,500	6,700	2,900	12,400	10,300	7,800	5,100	2,300
Air Speed, m.p.h.								
Indicator	105	118	133	98	108	113	123	132
Recorder	1.48	1.85	2.22	1.29	1.57	1.73	2.01	2.26
Temperature								
Deg. Cent	-16.5	-12.0	-11.0	-14.5	13.0	-7.5	-4.0	-5.0
Deg. Fahr	2.3	10.4	12.2	5.9	8.6	18.5	24.8	23.0
Engine Speed, r.p.m.	1,955	2,030	2,070	1,935	1,995	2,030	2,070	2,090
Air-Speed Recorder								
Distance Up, in.	0.33	1.76	3.39	0.35	0.40	1.29	2.38	3.63
Pressure								
Mm. of Mercury	507	587	675	469	512	561	621	688
In. of Mercury	19.96	23.11	26.57	18.46	20.16	22.09	24.45	27.09
H_p	10,780	6,970	3,240	12,768	10,530	8,160	5,480	2,730
H_p	9,550	5,360	800	12,240	9,730	7,450	4,500	960
$\sqrt{(\rho_0/\rho)}$	1.160	1.080	1.012	1.200	1.160	1.120	1.070	1.015
True Indicated Air-Speed, m.p.h.								
Indicator	103.0	115.0	130.5	97.0	106.0	110.5	120.5	129.0
Recorder	102.0	116.0	129.5	95.0	106.0	112.0	122.0	131.0
True Air-Speed, m.p.h.								
Indicator	119.5	124.0	132.0	116.5	123.0	124.0	129.0	131.0
Recorder	118.5	125.0	131.0	114.0	123.0	125.5	130.5	133.0

sure, the air density can be calculated. For a given true speed the true indicated air-speed is assumed to be proportional to the square root of the air density. The true air-speed is obtained by multiplying the true indicated air-speed corresponding to the observed air-speed by $\sqrt{(\rho_0/\rho)}$, which can be calculated or read from a chart similar to that in Fig. 13.

Table 3 illustrates the calculation of speeds at altitudes. A single determination of true speed at high altitude has a precision no better than about 3 per cent. By establishing a mean curve from a large number of speeds obtained at various altitudes on different flights or over different terrain, an accuracy within 1 per cent can probably be reached for true speeds up to 75 per cent of the ceiling of the airplane. An example of speeds obtained and the mean curve assumed is given in Fig. 14.

In the case of an airplane using a super-compressed

FIG. 13—VARIATION OF $\sqrt{(\rho_0/\rho)}$ WITH ALTITUDE

A Chart Similar to This, Together with the Air-Speed Indicator or Recorder Calibration, Is Used To Obtain the True Air-Speed from the Observed Value

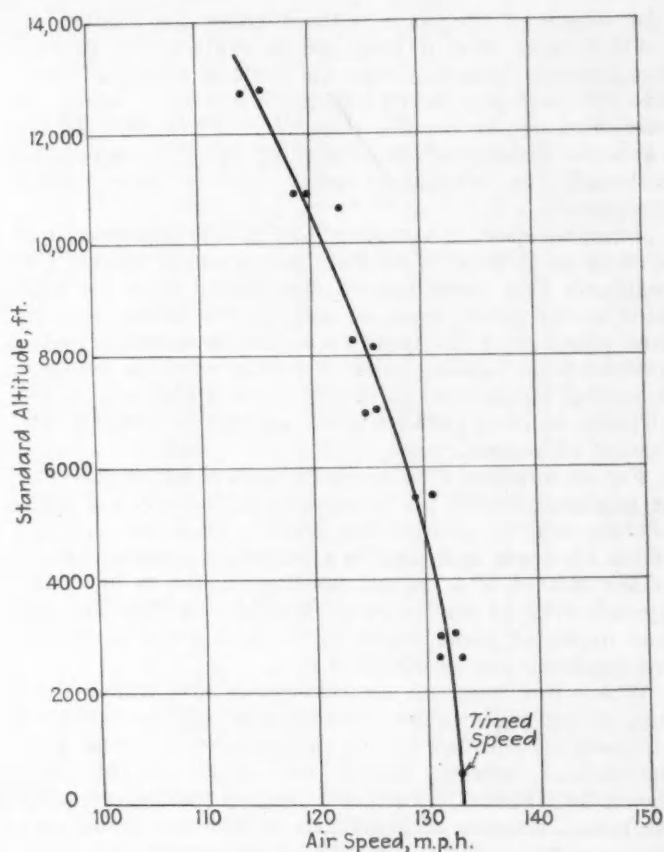


FIG. 14—AN EXAMPLE OF THE OBSERVED SPEEDS AND THE ASSUMED SPEEDS AT VARIOUS ALTITUDES

engine, the speed at the critical altitude may be in excess of that which can be safely attained at sea-level. Due, however, to the effect of air density on the air-speed indicator reading and the variation of power and air density with altitude, calibrating the air-speed indicator over a sea-level course at the reading shown at maximum speed at the critical altitude is usually possible without danger to the powerplant.

Certain points of interest in connection with determining speeds at altitude are as follows:

- (1) Speed is directly dependent on engine operation which involves proper use by the pilot of mixture and heat controls.
- (2) Statorscope indications may be erroneous due to temperature changes of the instrument.
- (3) After deciding on the correct air-speed indicator reading, change the speed to 1 or 2 m.p.h. above and then to the same amount below, observing whether corresponding changes in altitude follow.
- (4) Speeds at altitudes can be run conveniently on descents after climbs and, due to temperature differences, the statorscope is more likely to be dependable at that time than if speeds were determined while ascending.
- (5) Speeds should be determined at altitude intervals of about 2000 ft. up to 75 per cent of the ceiling.

Stalling and Landing Speeds

As an item of airplane performance, stalling speed under any condition is assumed to be the minimum sea-level speed at which the lifting surfaces will support

the weight of the plane without using the engine. In certain cases lack of longitudinal control may prevent the airplane from attaining the angle of attack at which the lift coefficient is the maximum and upon which the minimum speed usually depends. When this is the case, the determination of stalling speed is impossible although the minimum speed can be very readily measured.

Landing speed is considered to be the minimum sea-level speed at which a normal landing can be made. For seaplanes this speed has no dependence upon the attitude of the plane when at rest on the water, but for land planes it is the speed at which the airplane makes a three-point landing with minimum vertical velocity. A normal landing is one in which the flight path of the airplane becomes parallel to the ground or water at the instant of contact.

For an airplane with adequate control which can land at minimum speed, no measurable difference will exist between stalling and landing speed. Thus the readings of the air-speed indicator in a minimum-speed glide and at the instant of a normal landing should be identical. By referring to the air-speed indicator calibration, the true indicated speed, equal to the true speed at standard sea-level, can be obtained.

Where minimum or landing speeds are higher than that of the stall, similar observations of the indicated air-speed interpreted by the calibration curve will give the desired figures. Speeds determined in this way should be given to the nearest integral number of miles per hour. Greater accuracy can be attained under certain conditions but ordinarily is not worth the additional effort. Minimum speed with power can be determined in a similar manner.

Climb Characteristics

The maximum rates of climb at various altitudes and the length of time required to reach any given height are among the most important factors that make up the complete performance of an airplane. The determination of representative figures for a given plane requires considerable experience both in the actual flying and in the interpretation of results.

At any altitude only one air-speed will produce the maximum rate of climb for a given airplane. Several

means for determining this speed are available. Theoretically, the ideal way would be to make a series of climbs at different air-speeds through an altitude change of 1000 or 2000 ft., the desired speed being that for which the least time was observed. In practice this method is likely to give false or negative results due to conditions existing in the airplane and atmosphere. A method that gives satisfactory results is as follows:

- (1) Determine indicated maximum and stalling speeds at sea-level.
- (2) The indicated speed for maximum rate of climb at sea-level will be obtained from the equation

$$v_c = v_s + 1/3 (v_m - v_s)$$

where

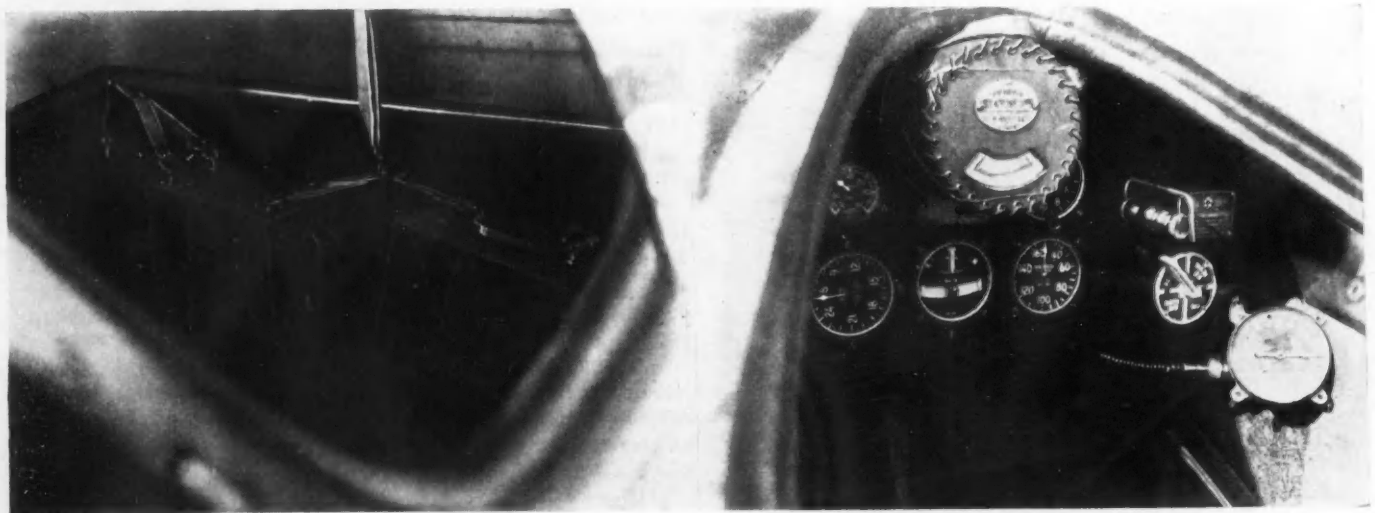
$$\begin{aligned} v_c &= \text{indicated speed in climb} \\ v_m &= \text{indicated maximum speed} \\ v_s &= \text{indicated stalling speed} \end{aligned}$$

- (3) The indicated speed for maximum rate of climb at service ceiling will be from 5 to 10 m.p.h. above indicated stalling speed at sea level.
- (4) Indicated speeds giving maximum rate of climb at other altitudes are obtained by linear interpolation between the values obtained in (2) and (3).

The experienced pilot will usually be able to determine during the first climb whether or not the assumed speeds are correct. In most cases the type of rate-of-climb curve with altitude, obtained by reduction of the observed data, will show whether the climb has been made at the speed giving maximum rate of all altitudes. Care and experience are necessary to detect and eliminate unreliable results.

At the start of every climb full load must be in the airplane. The necessary instruments, which include air thermometer, barographs, statoscope, altimeter, air-speed recorder and possibly oxygen equipment, must be properly installed.

The climb should be started by flying at ground level at the indicated speed that is to be used. The timing watch or chronograph is started as the throttle is opened and the airplane pulled up into the climb. The pilot maintains as closely as possible the speed that has previously been decided on for each altitude. Proper attention to the position of the horizontal stabilizer, when



Barograph and Air-Speed Recorder

Statoscope and Tachometer

FIG. 15—EXAMPLES OF INSTRUMENT INSTALLATIONS FOR OBTAINING FLIGHT-TEST DATA

TABLE 4—REDUCTION OF CLIMB DATA

Time, Min.	Air-Speed Recorder Distance Up, In.	Barometric Pressure		Temperature		hp., Ft.	hp, Ft.	Δh , Ft.	0.36 Δh ,		Engine Speed, R.P.M.
		Mm.	In.	Deg. Cent.	Deg. Fahr.				Ft.	H, Ft.	
0.00	4.82	754	29.68	- 4.0	24.8	220	-2,080	-2,300	-830	-610	1,760
1.35	4.10	715	28.15	- 6.5	20.3	1,680	-580	-2,260	-810	870	
2.80	3.43	677	26.65	- 6.5	20.4	3,160	1,300	-1,860	-670	2,490	
4.25	2.88	648	25.51	- 5.0	23.0	4,340	2,950	-1,390	-500	3,840	1,750
5.70	2.43	623	24.53	- 5.0	23.0	5,400	4,200	-1,200	-430	4,970	1,740
7.15	2.01	601	23.66	- 5.5	22.1	6,350	5,350	-1,000	-360	5,990	
8.60	1.67	582	22.91	- 6.5	20.3	7,200	6,320	- 880	-320	6,880	
10.05	1.34	563	22.17	- 8.5	16.7	8,070	7,140	- 930	-330	7,740	1,730
11.50	1.08	549	21.61	- 9.5	14.9	8,720	7,850	- 870	-310	8,410	
12.95	0.83	535	21.06	-11.0	12.2	9,390	8,500	- 890	-320	9,070	
14.40	0.60	523	20.63	-12.5	9.5	9,980	9,050	- 930	-330	9,650	1,720
15.85	0.34	508	20.00	-13.0	8.6	10,730	9,940	- 790	-280	10,450	
17.30	0.16	498	19.61	-13.0	8.6	11,240	10,560	- 680	-240	11,000	1,710
18.75	...	...	...	-14.0	6.8	...	...	...	...	...
20.20	0.24	478	18.82	-15.0	5.0	12,280	11,620	- 660	-240	12,040	
21.65	0.33	471	18.54	-15.5	4.1	12,650	12,020	- 630	-230	12,420	
23.10	0.42	463	18.23	-16.0	3.2	13,080	12,530	- 550	-200	12,880	
24.55	0.50	457	17.99	-16.5	2.3	13,410	12,840	- 570	-200	13,210	1,705
26.00	0.56	452	17.80	-17.0	1.4	13,690	13,150	- 540	-190	13,500	
27.45	0.63	446	17.56	-17.5	0.5	14,020	13,420	- 600	-210	13,810	
28.90	0.69	442	17.40	-18.0	-0.4	14,250	13,600	- 650	-230	14,020	1,680
30.35	0.74	438	17.24	-18.5	-1.3	14,470	13,900	- 570	-210	14,260	
31.80	0.78	434	17.09	-19.0	-2.2	14,700	14,050	- 650	-230	14,470	
33.25	0.82	430	16.93	-20.0	-4.0	14,930	14,250	- 680	-240	14,690	
34.70	0.87	426	16.77	-20.5	-4.9	15,160	14,430	- 730	-260	14,900	1,660
36.15	0.90	423	16.65	-20.5	-4.9	15,340	14,660	- 680	-240	15,100	
37.60	0.92	422	16.61	-20.0	-4.0	15,390	14,800	- 590	-210	15,180	
39.05	0.93	421	16.57	-20.0	-4.0	15,450	14,900	- 550	-200	15,250	1,640

These data were obtained with a C3-225 Spartan airplane, No. NC-708N, on Jan. 23, 1930, between 12:15 and 1:40 p. m. at Tulsa, Okla., by E. W. Rounds. The airplane weighed 2700 lb. at the start of the test flight and was equipped with a Hamilton design No. 1219 metal propeller having a blade angle of 15.3 deg. at 42 in. and a diameter of 8 ft. 8 in.

adjustable, assists greatly in flying at the desired air-speed.

During the climb the pilot may take the necessary data himself or an observer may be used. A skilled pilot can readily record all necessary data without sacrifice of accurate flying and has the advantage over an observer in being better able to note powerplant operation and irregularities in the flight that later may assist greatly when interpreting results. For the first part of the climb, when the rate is high, observations should be recorded every 2 min., whereas at greater altitudes longer intervals of time are sufficient. In addition to holding the correct air-speed and recording the data, the pilot must manipulate the mixture and heat controls in such a way as to maintain the maximum number of engine revolutions per minute. He should also keep his oxygen flow at the correct rate; adjust the horizontal stabilizer as necessary, watch fuel and oil pressures, oil and water temperatures, cylinder-head and flange temperatures and fuel quantity; and keep the position of his landing-field in mind.

The climb should continue to an altitude above service ceiling. This is usually reached when the altimeter change averages 100 ft. per min. Most airplanes reach their service ceiling in less than 45 min. and few climbs longer than this are necessary. Actual details of procedure will vary but the following suggestions should assist in securing reliable climb-data:

- (1) If practicable, start the climb across the wind to eliminate the effect of high wind-gradient close to the ground.
- (2) Make as few and as large-radius turns as possible.
- (3) Avoid flying over cities and mountainous areas.
- (4) Avoid the leeward side of cities at all altitudes.

- (5) Avoid clouds, particularly the areas above and below them.
- (6) After reaching service ceiling, try speeds above and below the assumed proper speed as a check on the latter.
- (7) End the climb on an integral minute, diving sharply to indicate its termination on the barograph record. This assists later in synchronizing pressure and temperature.
- (8) Mount all recording instruments in shock-absorbing suspension.
- (9) Carry two barographs whenever convenient. One may prove to be defective.
- (10) A drum speed of one revolution or less per hour is satisfactory for recording instruments.
- (11) Use smoked charts rather than pen and ink.
- (12) Mount the air thermometer away from the influence of the powerplant and protect the bulb from direct rays of sun.
- (13) Use an air thermometer with a small lag for fast-climbing airplanes.
- (14) Using an adjustable stabilizer for balance aids in keeping steady air-speed.
- (15) Fig. 15 shows satisfactory methods of installing test instruments in the airplane.

Climb data should be reduced in such a way that the same results will be reached after reduction to standard whatever the atmospheric conditions at the time of the climb. Various methods have been proposed and tried, the best at present being that evolved by Diehl⁶. The standard atmosphere to which all performance should be reduced is defined in National Advisory Committee for Aeronautics Report No. 218.

The results of a climb are presented in Table 4. The data obtained on this and one other climb are plotted in Fig. 16.

The final climb-characteristics have been plotted in

⁶ See Engineering Aerodynamics, by W. S. Diehl; also National Advisory Committee for Aeronautics Report No. 297.

Fig. 17. Rate and times of climb at various altitudes can be read from the curves. The service ceiling is where the rate of climb is 100 ft. per min.

Conclusion

An attempt has been made in this paper to give, in sufficient detail, methods for determining items of airplane performance which are valuable to the manufacturer for advertising purposes and which can be reduced to a basis permitting comparison with other data obtained in a similar manner. As indicated in the opening paragraphs and to assure that published performance-data be reliable, the methods of test and interpretation of data should be approved by some organization that is not under the control of the airplane manufacturer. Since the Aeronautics Branch of the Department of Commerce has apparently abandoned its original idea of issuing certificates of performance when properly obtained, the Aeronautical Chamber of Commerce of America, Inc., is suggested as being best fitted to exercise this function. An organization charged with the approval of performance data should be headed by an aeronautic engineer having the necessary qualifications; include engineering inspectors who are competent pilots, sufficient in number to meet the conditions as they arise; and be prepared either to conduct, supervise or witness performance tests.

To guard against the approval of unreliable data, certain requirements must be fulfilled when the tests are neither conducted nor supervised by the approving agency. Using those formulated by the Aeronautics Branch of the Department of Commerce as a basis, the following regulations are suggested:

- (1) Before conducting flight tests to obtain performance data for the approval of —, the manufacturer shall arrange with — for the presence of an engineering inspector at the place of test.
- (2) Every facility shall be given the engineering inspector in checking the condition of the airplane and powerplant.
- (3) The flight tests and reduction of data must be made under the supervision of a responsible engineer who will certify by affidavit that all requirements have been complied with.
- (4) Due to the difficulties encountered in securing certain flight-data, — will approve only the following items of performance:
 - (a) Maximum horizontal speeds to 75 per cent of service ceiling
 - (b) Minimum speed without power at sea level
 - (c) Rate of climb at various altitudes
 - (d) Times of climb to various altitudes
- (5) To be eligible for approval, performance must be obtained on an airplane that has received an approved-type certificate and is powered with approved-type engine-propeller unit or units.
- (6) The data obtained and the methods of testing must be satisfactory to the engineering inspector and finally to — insofar as they are involved in the results submitted for approval.
- (7) The pilot, if an employee of the manufacturer, must be accompanied on test flights by an unprejudiced observer. The pilot, if not an employee of the manufacturer but engaged by the supervising engineer, need not be accompanied by an observer except on timed speed-runs,

when he shall be accompanied by the engineering inspector.

- (8) The following instruments, appropriate for the test in question, must be used in obtaining the performance data:
 - (a) Air-speed indicator
 - (b) Air-speed recorder
 - (c) Altimeter
 - (d) Barograph
 - (e) Tachometer
 - (f) Strut thermometer or equivalent
 - (g) Stop-watch
 The instruments must be of reputable make and in good working order. Additional instruments may be used.
- (9) Calibration of the air-speed indicator and air-speed recorder shall be made in an approved manner by flying over a measured course or its equivalent. Calibration of the barograph, tachometer, strut thermometer and stop-watch shall be made by the Bureau of Standards, City of Washington, and evidence satisfactory to — shall be presented that the calibration submitted applied at the time of the tests.
- (10) The measured course shall be not less than 2 statute miles in length, and the difference in altitude between the two ends shall be not greater than 50 ft.
- (11) Maximum timed speed at ground level shall be

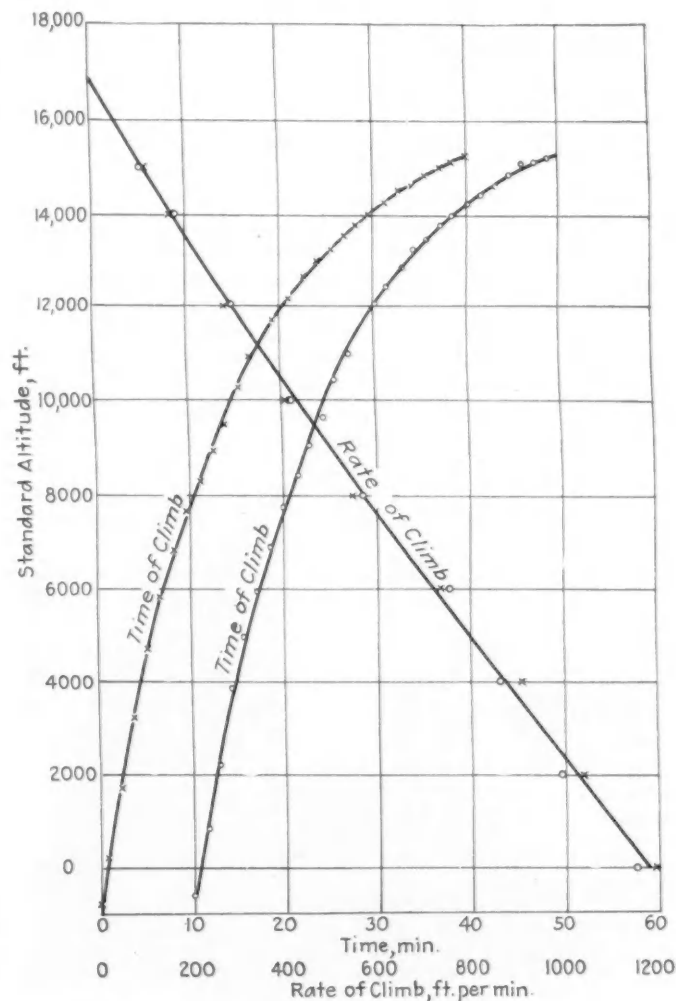


FIG. 16—CHART SHOWING DATA OBTAINED FROM TWO CLIMBING TESTS

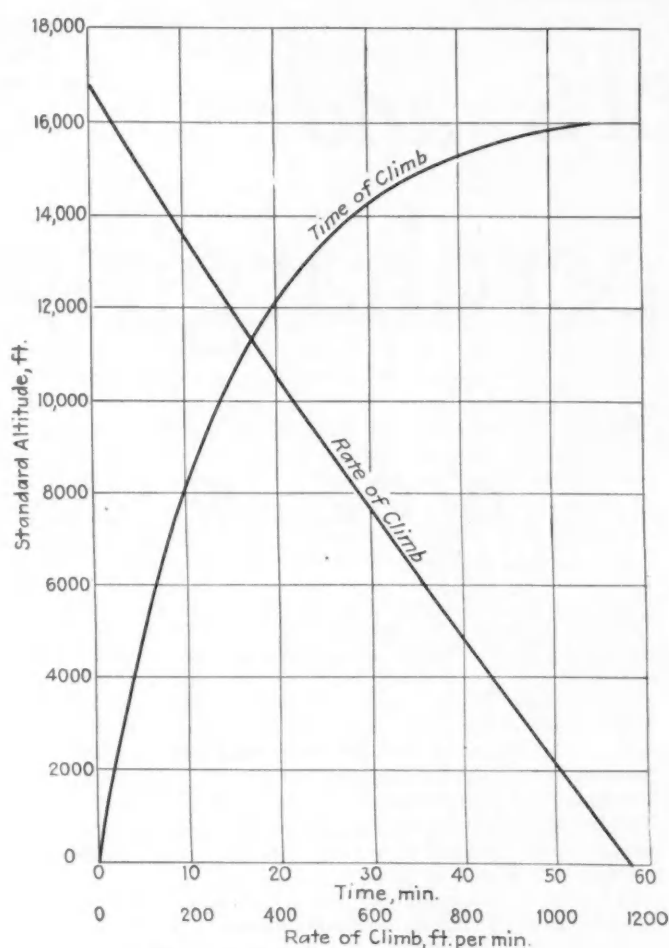
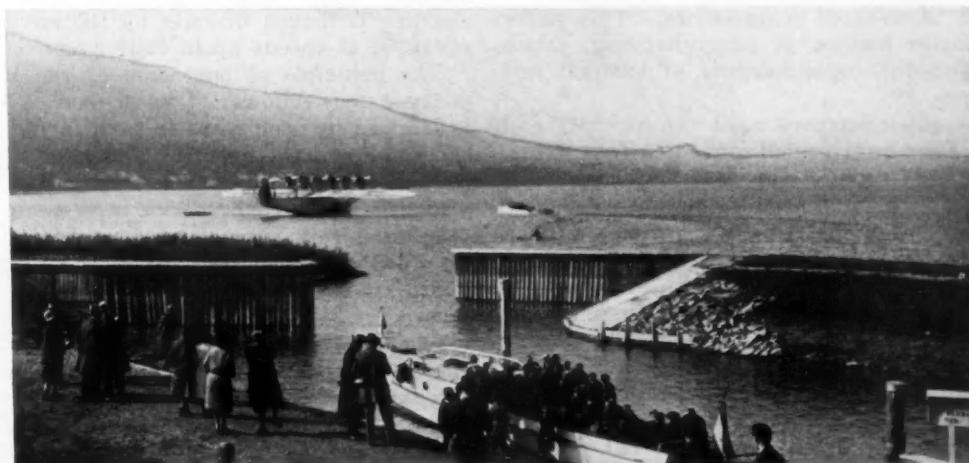


FIG. 17—FINAL CLIMB-CHARACTERISTICS OF A C3-225 SPARTAN AIRPLANE WEIGHING 2700 LB.

determined by the average of not less than six consecutive runs over the measured course, the runs being alternately with/against and against/with the wind.

- (12) The full-load weights of the airplane shall be the maximum allowed by the approved-type certificate.

- (13) All data submitted must have been obtained with the same propeller specifications. The use of different blades or settings for climb and maximum speed will not be permitted.
- (14) The maximum revolutions per minute of any engine at full throttle in level flight shall not exceed 105 per cent of the rated revolutions per minute as given in the approved-type certificate. The maximum revolutions per minute shall be considered to be the rate obtained with such settings of mixture control and carbureter heater as will give maximum revolutions per minute.
- (15) The scales used in weighing the airplane and useful load shall be certified as correct or the calibration be submitted by the local City Sealer of Weights and Measures or the Bureau of Standards.
- (16) Application for approval of performance data shall include:
- (a) Affidavit of manufacturer that the airplane tested was built and loaded in accordance with its approved-type certificate
 - (b) Affidavit of manufacturer that the engine was in accordance with appropriate approved-type certificate
 - (c) Affidavit of responsible supervising engineer that tests were conducted in accordance with — requirements
 - (d) All records made by recording instruments
 - (e) All readings taken from indicating instruments
 - (f) Calibrations of all instruments
 - (g) Affidavit of surveying agency or county engineer as to length of course and difference in altitude of its two ends
 - (h) Complete computations including any special charts or methods used in reduction of data
 - (i) Names of pilot and observer
 - (j) Name of engineering inspector witnessing tests
 - (k) Dates and places of various test-flights
 - (l) Photographs showing airplane as tested and method of installing instruments
 - (m) Affidavit and calibrations covering scales
 - (n) Affidavit of manufacturer as to fuel and oil used during test



Superchargers and Supercharging

19th National Aeronautic Meeting Paper

By Oscar W. Schey¹

CLASSIFYING the superchargers used for present aircraft and automobile service as Roots, centrifugal and vane types, the author states that the vane type for this service is a more recent development than the other two and describes each type. He states further that the ideal type should satisfy many requirements closely related with those of a well-designed engine—such as being light, compact and reliable—and that the practice of supercharging has increased considerably during the last few years.

The comparative performance of superchargers is treated at some length, and engine-performance data are presented. The power developed by an engine equipped with a turbo supercharger is illustrated by curves, control methods are compared, net engine-power is computed, and flight-test data on comparative performance are analyzed.

After discussing the effect of supercharger capacity on performance, the author states that, in the selec-

tion of a supercharger for use on an airplane designed to meet definite performance requirements, the question arises whether it is advisable to choose a supercharger of sufficient capacity to maintain sea-level pressure to the maximum useful altitude or to choose one of smaller capacity that requires less power. Selection of the best supercharger-capacity depends largely upon the way in which the type of supercharger in question affects the engine power, the percentage of engine power required by the supercharger and the kind of service for which the supercharged engine will be used.

Following a statement of the influence that supercharger capacity has on performance and an analysis of the effect of "boosting," the author concludes that the supercharging of engines of low compression-ratio is impracticable and that it is desirable that an engine have a compression ratio of at least 4.5:1 for supercharging.

SUPERCHARGING is the increasing of the weight of charge delivered to an engine in excess of that normally inducted at the prevailing atmospheric pressures and temperatures. It can be accomplished to a small extent by the use of long intake-pipes by taking advantage of the ramming action of the air. When a large increase in mixture weight is desired, it is necessary to resort to blowers or compressors. This paper deals with the latter method of supercharging, which now is in vogue in the supercharging of aircraft and automobile engines.

At present the superchargers used for aircraft and automobile service can be classified conveniently as Roots, centrifugal, and vane types. The first two have been used extensively since the advent of the supercharging of aircraft engines, while the vane type for this service is a more recent development. A sketch of each of these three types of supercharger is shown in Fig. 1.

The Roots type consists essentially of two symmetrical rotating elements enclosed within a casing. The casing usually is made of an aluminum alloy ribbed for strength and cooling. The rotating elements or impellers have cycloidal contours except for the tip, which forms the arc of a circle, and for a narrow flat portion

at the hub. The impellers are made from steel or a light alloy, the light metal being in more general use for aircraft-engine superchargers. The impellers are rotated in opposite directions by gears. They do not contact with each other nor with the casing; however, the clearances are reduced to the minimum to reduce the amount of air that slips back. This type of supercharger is driven directly by the engine and has been operated at speeds up to 7000 r.p.m.

The principle of operation of the Roots-type supercharger is as follows: Low-pressure air enters at *a* and is trapped by each rotor in turn in the space *b* between the rotor and the casing. The instant the tip *c* of the rotor passes the corner *d*, the high-pressure air on the discharge side rushes back and compresses the low-pressure air in space *b*. Further rotation of the rotor for about 180 deg. is against the discharge pressure. There are four discharge pulsations for each revolution, or two for each of the two impellers.

The centrifugal supercharger consists of a rotating impeller enclosed within a casing. In well-designed superchargers both the impeller and the casing are provided with vanes to guide the air as it enters and is discharged. Alloys of aluminum and magnesium have been successfully employed for the construction of the casing and the impeller. To eliminate the thrust on the

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bearings, superchargers of this type are frequently designed so that half the air is taken in on each side and near the center of the high-speed impeller.

The blades *e* are designed so as to receive the air without shock and to give maximum stiffness to the impeller. The rapid rotation of the impeller causes the air to have a high velocity at the impeller exit due to the action of centrifugal force. The high-velocity air is discharged into diffuser vanes *f*, which are so designed that the velocity head is efficiently changed to a pressure head.

This type of supercharger may be driven directly by the engine through gears of sufficient ratio to give the high rotative speeds necessary, or it may be driven by an exhaust-gas turbine. When driven by a turbine, the exhaust gases from the engine are collected in a nozzle box, from which they pass through nozzles to the turbine wheel, which is coupled directly to the supercharger.

The vane type of supercharger consists of a series of vanes mounted on a drum which is eccentrically located within a cylindrical casing. As the drum *g* rotates about the center *h*, the vanes *i* move out against the casing under the action of springs and centrifugal force or by mechanical means. If the vanes are moved by mechanical means, as has been found most satisfactory, they usually operate with a slight clearance rather than in contact with the casing.

The air enters the supercharger at *j* and, as the vanes revolve, the air is trapped between two successive vanes. As this air moves toward the discharge side the volume between the vanes is decreased, and thus the air is compressed. The high-pressure air is discharged through the opening *k*. This type of supercharger is driven directly by the engine.

Requirements To Be Satisfied

The ideal type of supercharger should satisfy many requirements closely related with those of a well-designed engine. It should be light, compact and reliable. From a maintenance viewpoint it should be accessible and require very little attention so far as overhauling and repairing are concerned. Probably its most important requirements are that its operation should require only a small percentage of engine power, and that it

should cause the minimum increase in discharge-air temperature.

The practice of supercharging has increased considerably during the last few years. Superchargers now are used on automobile engines to supply air at pressures higher than atmospheric, on aircraft engines to compensate for diminution of atmospheric pressure at altitude as well as to boost the pressure slightly during take-off and during flight at low altitudes, and on Diesel engines to supply the air for both combustion and scavenging.

Considering the varied uses of superchargers and the many requirements they must satisfy, it is reasonable to expect that each of these superchargers has a field in which it is superior to the other types, or that one type will meet all the service requirements better than either of the other types. To select the supercharger best suited for a particular condition of service, or for all service conditions, a knowledge of the performance characteristics and the mechanical limitations of each type is essential.

Comparative Performance of Superchargers

One of the most important characteristics of an aircraft-engine supercharger is the power required to compress air at a given rate for the desired range of altitudes; in other words, the percentage of engine power required by the supercharger to maintain sea-level pressure at the carburetor. In an investigation made by the National Advisory Committee for Aeronautics a rate of flow of 1 lb. of air per sec. was assumed, this being the quantity of air required by a well-designed engine of 492 hp. The theoretical power required to compress air flowing at this rate from atmospheric pressure to 29.92 in. of mercury was computed for altitudes from 0 to 40,000 ft. These power requirements were computed for a series of compression exponents from 1 to 2.

When determining the power required for the compression of 1 lb. of air per sec. for the range of altitudes and the pressure conditions mentioned, the equation $Hp. = CP_1 V_1 \log_e r$ was used for the isothermal condition, and the equation $Hp. = C [n/(n-1)] [P_1 V_1] [r^{(n-1)/n}]$ for the polytropic condition.

In these equations P_1 represents the intake or atmos-

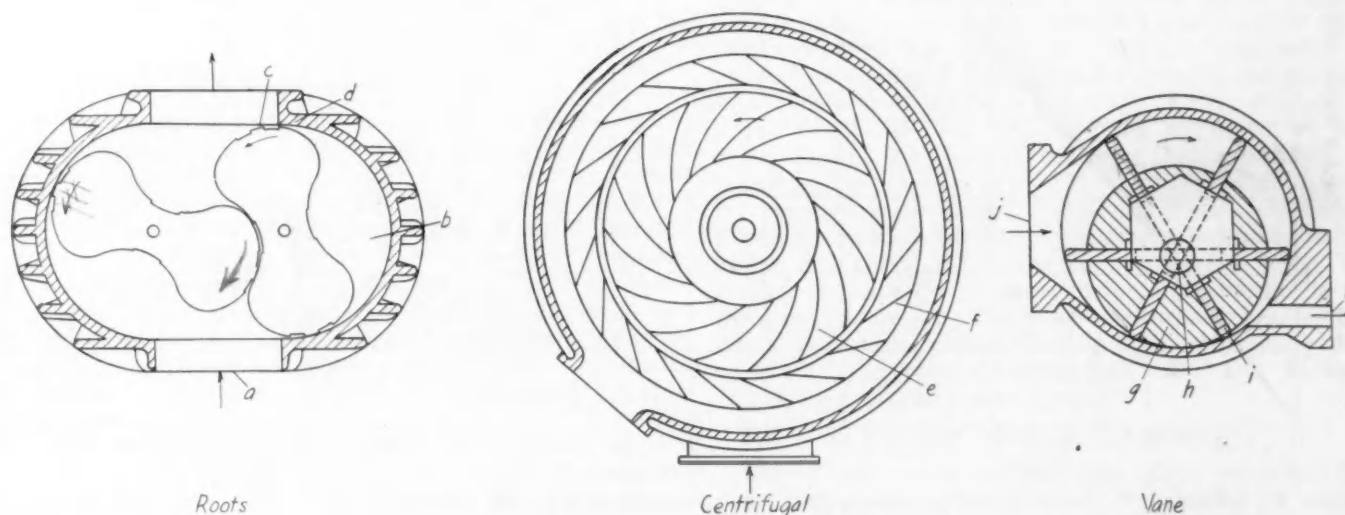


FIG. 1—REPRESENTATIVE TYPES OF SUPERCHARGER

pheric pressure; V_1 , the volume of intake air displaced per second; r , the compression ratio; C , a constant depending on the units used; and n , the compression exponent. The theoretical power required by a Roots supercharger to compress 1 lb. of air per sec. was also computed for the range of altitudes, pressure, and compression conditions already mentioned, using the equation $Hp = C V_1 (P_2 - P_1)$. In this equation P_2 is the discharge pressure.

The curves in Fig. 2 were obtained by plotting the results of these computations. If an over-all efficiency of 70 per cent is assumed for each of the two types of compressors, then the power required to compress 1 lb. of air per sec. is greater for the Roots type of supercharger by 3.49, 16.96, 47.35 and 111.32 hp. at altitudes of 10,000, 20,000, 30,000 and 40,000 ft., respectively, than it is for a supercharger which operates with polytropic compression of exponent 1.6.

In the study of these theoretical power-curves remember that sea-level pressures are maintained at the carburetor for a large range of altitudes, but that few supercharger installations maintain sea-level pressure at the carburetor for altitudes above 20,000 ft. These theoretical curves show that a supercharger operating on the constant-pressure process, as the Roots, would be satisfactory from a power viewpoint for low and for moderate altitudes, but for high altitudes its operations would require too much power.

The effect of the compression exponent n on the discharge-air temperatures was also determined for the range of altitudes and for the pressure and compression conditions used in the power computations. The

discharge-air temperatures for polytropic compression were determined from the thermodynamic relation

$$(P_2/P_1)^{(n-1)/n} = (T_2/T_1) \quad (1)$$

in which T_1 = the intake temperatures in degree fahrenheit, absolute; and T_2 = the discharge-air temperatures in degrees fahrenheit, absolute. The pressures and temperatures for a standard atmosphere, given in N.A. C.A. Technical Report No. 216, were used in these computations.

The curves in Fig. 3 were obtained by plotting the results of these computations. A supercharger operating in a standard atmosphere and having a 1.235 exponent gives a constant discharge-air temperature up to the stratosphere; that is, at an altitude of about 35,300 ft. Besides reducing the theoretical power required to compress the air, as shown in Fig. 2, a low compression-exponent gives lower discharge-air temperatures, as shown in Fig. 3. This reduction in supercharger discharge-air temperatures increases the engine power, because a greater weight of charge can be inducted, and it also permits the use of a smaller cooler.

An analysis of the flight-test data obtained with the turbo-supercharger and with the Roots type of supercharger shows that each of these superchargers heats the discharge air to a condition corresponding to that with a compression exponent of 1.6. If this compression exponent could be reduced to 1.235, for an engine consuming 1 lb. of air per sec., gains in engine power of 16.6, 23.8, 53.4 and 79.9 hp. would be effected at altitudes of 10,000, 20,000, 30,000 and 40,000 ft., respectively. These values are based on the temperatures given in Fig. 3 and on the assumption that the engine

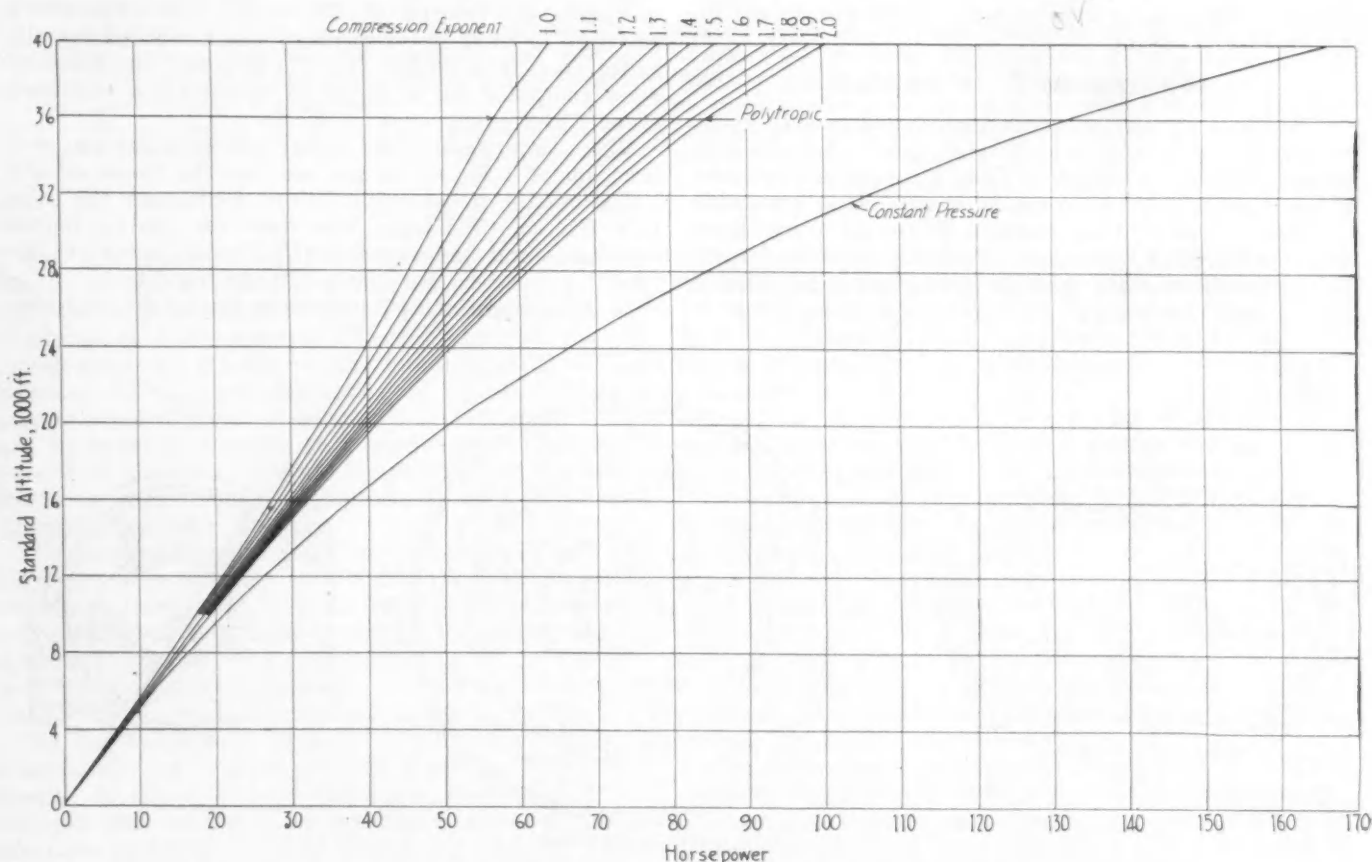


FIG. 2—POWER REQUIRED TO COMPRESS 1 LB. OF AIR PER SEC.

Compression Is from Atmospheric Pressure to 29.92 In. of Mercury at Standard Altitudes from 0 to 40,000 Ft. by a Supercharger Operating on a Constant-Pressure Card and One Operating on a Polytropic Card

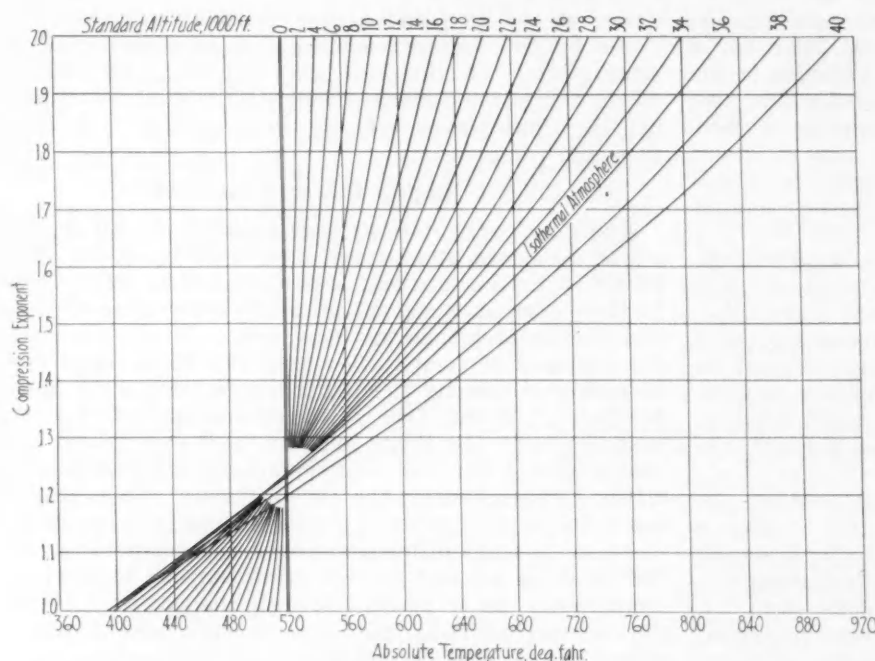


FIG. 3—EFFECT OF COMPRESSION EXPONENT ON DISCHARGE-AIR TEMPERATURES
From Data Obtained When Compressing Air of Standard Temperature and Pressure from Atmospheric Pressure to 29.92 In. of Mercury at 0 to 40,000 Ft. Using a Series of Compression Exponents from 1 to 2 Inclusive.

power varies inversely as the square root of the absolute temperature. The saving in supercharger power effected by reducing the compression exponent from 1.6 to 1.235 would be small compared with the gain in engine power due to the lower carbureter-air temperatures. For a supercharger of 70-per cent over-all efficiency, these gains amount to 0.94, 4.13, 9.85 and 19.71 hp. at altitudes of 10,000, 20,000, 30,000 and 40,000 ft., respectively.

The design of a supercharger that would operate with a compression exponent as low as 1.235 and that would compress the large volume of air consumed by an aircraft engine would be difficult, if not impossible, because no satisfactory means for removing the heat of compression could be provided. An air-cooler would, therefore, be necessary to obtain a constant air-temperature. The use of a small cooler would be possible if a supercharger of high efficiency were chosen, because low discharge-air temperatures would then be obtained.

Engine-Performance Data

Regarding comparative engine performance, both unsupercharged and supercharged and with different types of superchargers, the net engine power developed with each type of supercharger was computed for critical altitudes from 0 to 40,000 ft. The critical altitude is the maximum altitude to which sea-level pressure can be maintained at the carbureter. The unsupercharged engine power and the maximum developed engine power were also determined for the same range of altitudes. These computations were based on a hypothetical engine of good design developing 100 b.hp. at sea level.

For the determination of the power output of the unsupercharged engine for the range of altitudes investigated, the assumption was made that the engine speed was constant and that the engine power varied according to the relation

$$[(P_2)/29.92]^{1.18} \cdot [(T_2)/518]^{-0.8}$$

This relation is supported by a large amount of experimental data.

In computing the maximum brake-horsepower developed by the supercharged engine, the assumptions were that the carbureter temperature at all altitudes was 59 deg. fahr., that the carbureter pressure was 29.92 in. of mercury, and that the engine speed was constant. The test data obtained in a number of supercharged flights and the computations on discharge-air temperatures submitted in this paper indicate that, having a well-designed supercharger, one can use a cooler of sufficient capacity to maintain sea-level temperature at the carbureter. The engine speed could be maintained constant by the use of a variable-pitch propeller.

The effect of reduced exhaust-pressures on the power developed by an engine of 100 b.hp. at sea level was computed for altitudes from 0 to 40,000 ft. These computations were based on the results of tests recently conducted by the Bureau of Standards on a Curtiss D-12 engine, in which it was found that there was an increase of 2.56 hp. for each inch of mercury reduction in exhaust back-pressure.

The power required by the supercharger was subtracted from the total power developed by the engine to obtain the net engine power in the case of the superchargers of the Roots, the geared centrifugal and the vane types. Before this value of supercharger power was used in the computations, it was corrected for the increased volumetric efficiency of the engine operating with atmospheric pressure at the exhaust. This correction was based on the results of tests recently conducted by the Bureau of Standards.

The power developed by an engine equipped with a turbo supercharger was obtained by assuming that for any altitude the exhaust pressure was equal to the carbureter pressure, which was 29.92 in. of mercury. This assumption is supported by a large number of experimental data. Assuming a constant carbureter-air temperature of 59 deg. fahr. and a constant engine-speed, the engine equipped with a turbo supercharger has the same power at all altitudes up to the critical altitude.

The results of these computations are shown by the curves in Fig. 4. These curves show that, regardless of the type of supercharger used for altitudes below 20,000 ft., the differences in net engine power are very small. However, as the altitude of operation increases above 20,000 ft., these differences in net engine power increase, showing the exhaust turbo supercharger to be the most favorable. The Roots supercharger gives the lowest net engine power of all at high critical-altitudes, as would be expected from the fact that it has the least efficient method of compression.

Control Methods Compared

One should remember that these curves represent the results that would be obtained if a series of superchargers of each type were used in which each supercharger of the series was designed for one particular

altitude. In practice it is necessary to consider, instead, the single supercharger that is best fitted for a range of altitudes. As this range of altitudes is increased, each supercharger will be affected. The size of the effect will depend principally upon the method of control used, the ideal method being one in which the quantity of air taken into the supercharger is varied, without throttling, to be just enough to satisfy engine requirements.

With the turbo supercharger the method of control, though not ideal, is nevertheless very satisfactory. The quantity of compressed air and the amount of compression are regulated by the quantity of exhaust gas passing through the turbine wheel. The supercharger is designed to supply enough air to satisfy engine requirements up to some definite altitude, the altitude being that at which all the exhaust gases pass through the turbine wheel.

Such an excellent method of control is used on the exhaust turbo supercharger that the curves shown in Fig. 4 for a series of this type, each one being designed for one particular altitude, probably would represent closely the curve made by one supercharger used for the entire range. If this supercharger were designed, however, for a particular critical-altitude, such as 20,000 ft., the power curves shown in Fig. 4 would not then represent the power conditions above that altitude, because the carbureter pressures would be less than 29.92 in. of mercury and the effect of back pressure on power would increase as the carbureter pressure decreased.

The method of control used on the Roots supercharger is not so satisfactory as that of the exhaust turbo supercharger. The Roots type is driven directly from the engine and is designed to maintain ground-level pressure up to some definite altitude. Too much air is supplied to the engine at altitudes below the critical altitude unless some of the air is bypassed. A supercharger designed for a critical altitude of 20,000 ft. should bypass at sea level about 40 per cent of the air. However, at low altitudes little energy has been expended in compressing the large amount of bypassed air and, near the critical altitude where the required energy is greater, only a small amount of air is bypassed. The lower the critical altitude is for any supercharger, the less air is bypassed at sea level, and proportionally less energy is wasted, below the critical altitude, in compressing air and then bypassing it.

On the geared-centrifugal supercharger, the throttling method of control is used. The air entering the supercharger at sea level and at low altitude is throttled until just enough air is admitted to satisfy engine requirements at sea level. Throttling the air at the supercharger inlet to limit the quantity inducted makes it necessary to compress the throttled air so that it will be discharged at sea-level pressures. Considering the net engine power, this method is very unsatisfactory because the engine

power at sea level and at low altitudes is greatly reduced by two factors: (a) the loss of power used in compressing the throttled air, and (b) the loss in power due to the decreased weight of the charge caused by the high carbureter-air temperatures resulting from the compression.

Net Engine Power Computed

Additional computations were made on the net engine power developed at altitudes from 0 to 40,000 ft. with 20,000-ft. critical-altitude superchargers of each type. In these computations, the effort of the method of control used on each type was considered. It was assumed, for purposes of computation, that the cooler used was of sufficient capacity to maintain a carbureter-air temperature of 59 deg. fahr. to the critical altitude for the condition with the Roots and the turbo-centrifugal superchargers. For the conditions with the geared-centrifugal supercharger, the carbureter-air temperatures below the critical altitude were corrected for the large increase in temperature caused by the compression of the throttled air and for the reduction due to drop in temperature as it passes through the cooler. Above the critical altitude, the supercharger discharge-air temperatures were corrected for the temperature drop through the cooler to arrive at the carbureter-air temperatures. For the conditions with the Roots and the geared centrifugal superchargers, the engine and the supercharger power were corrected for the increased volumetric efficiency at altitude.

The comparative performance obtained with 20,000-ft. critical-altitude superchargers of different types, as shown by the curves in Fig. 5, indicates that there is very little difference in the performance above the critical altitude. Below the critical altitude the geared cen-

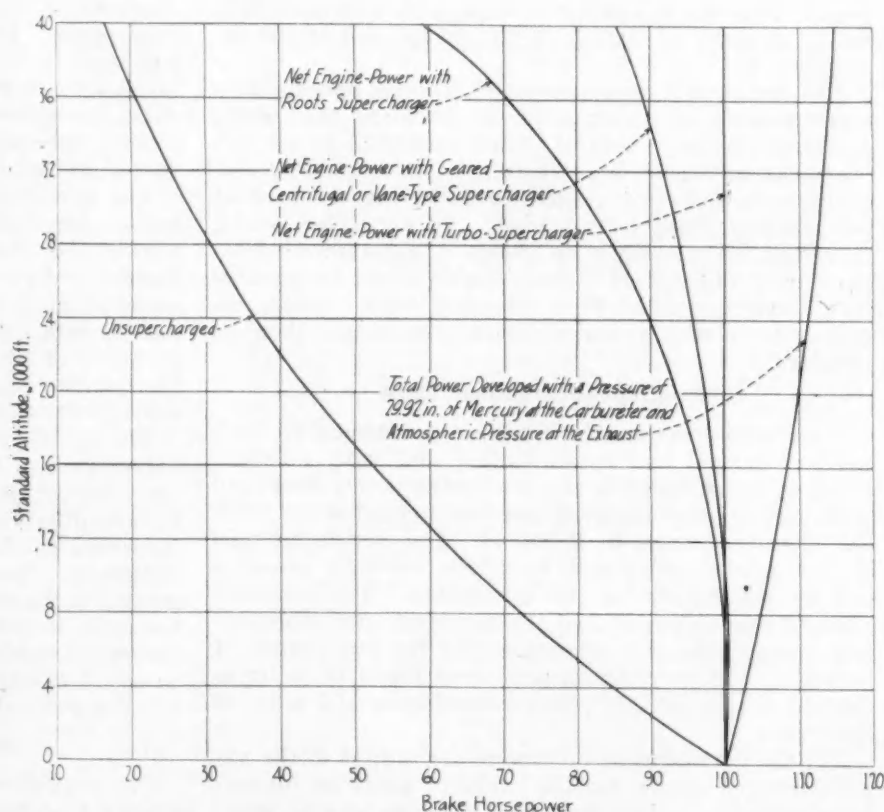


FIG. 4—POWER DEVELOPED BY AN UNSUPERCHARGED AND A SUPERCHARGED 100-HP. ENGINE AT SEA LEVEL

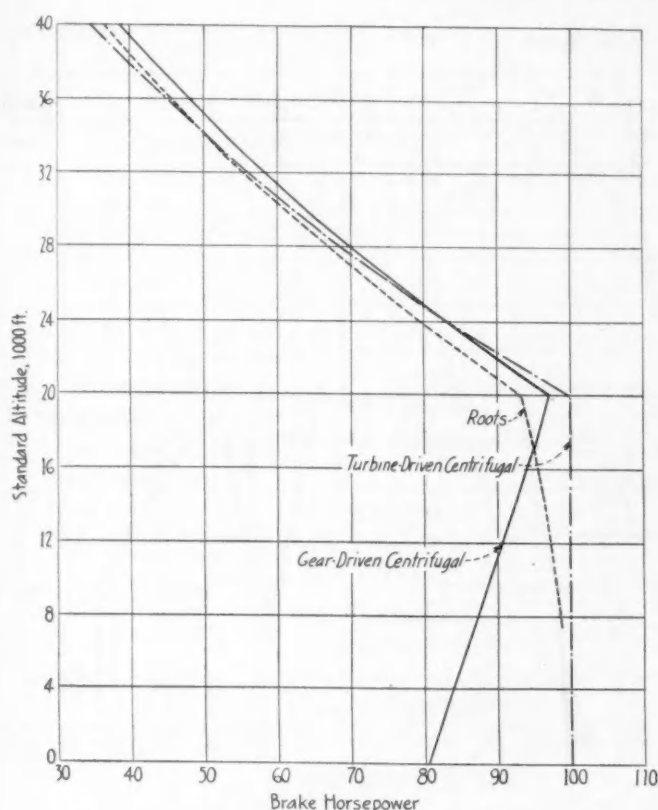


FIG. 5—NET ENGINE POWER AT ALTITUDE
Obtained when Supercharging a 100-Hp. Engine with Different
Types of Superchargers of 20,000-Ft. Critical-Altitude

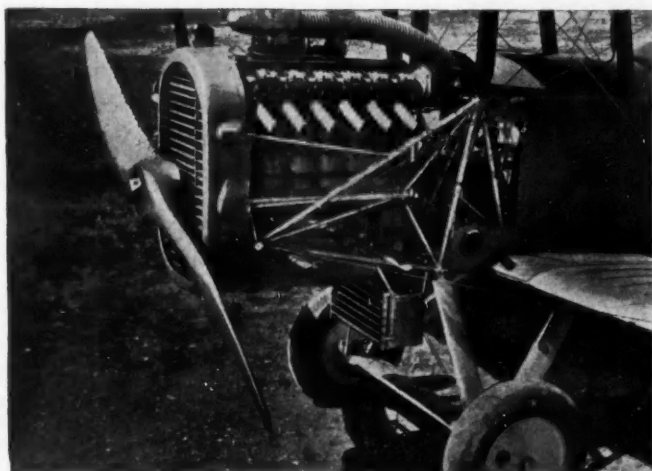


FIG. 6—ROOTS SUPERCHARGER
INSTALLATION IN A MOD-
IFIED DH-4M2 AIRPLANE



FIG. 7—TURBO-SUPERCHARGER INSTALLATION IN A MODIFIED DH-4M2 AIRPLANE

trifugal supercharger gives the lowest net engine power because of its very inefficient method of control. With superchargers of higher critical-altitude capability, the best performance above and below the critical altitude would be obtained with turbo-centrifugal superchargers. The Roots type for high critical-altitudes would be the least efficient at and above the critical altitude.

Flight-Test Data on Comparative Performance

These data were obtained from alternate use of turbo-centrifugal and Roots superchargers, the National Advisory Committee for Aeronautics having conducted flight tests to obtain the comparative performance. In these tests, both supercharger installations duplicated previous service installations as nearly as possible. The Roots supercharger installation is shown in Fig. 6 and the turbo-centrifugal installation can be seen in Fig. 7. A DH-4M2 airplane powered with a Liberty-12 engine was used. The weight of the airplane fully serviced, including the instruments and the pilot, was approximately 4300 lb. when equipped with the Roots-type supercharger, and 4350 lb. when equipped with the turbo-centrifugal type. The weight added to the airplane by each supercharger installation was 150 lb. for the Roots type and 167 lb. for the turbo-centrifugal. These weights include all air ducts and mounting brackets.

The Roots supercharger used had a displacement of 0.382 cu. ft. per revolution and was driven through a flexible coupling from the rear of the engine crankshaft. The capacity of the supercharger could be varied by changing the gear ratio between the driveshaft and the supercharger impellers. In these tests, drive-gear ratios of 2.4:1 and 3:1 were used. The turbo-supercharger used is known as form F-1A and is rated at 20,000-ft. critical-altitude for an engine of 812-cu. ft. displacement per min. The maximum rotative speed of the impeller is given as 23,150 r.p.m.

Fig. 8 shows the time-of-climb and the rate-of-climb curves for the six flights for which performance data were obtained. It is evident that the turbo-supercharged flights correspond more nearly to flight No. 4, using the Roots supercharger with the 3:1 drive-gear ratio, than to flight No. 5, using the 2.4:1 drive ratio. Although the differences in ceiling and rate of climb with the two superchargers are no greater than those between

successive flights with either supercharger, what differences there are indicate slightly better performance with the turbo supercharger. Flight No. 3, unsupercharged, with the turbo supercharger installed, shows slightly lower ceiling and poorer rate of climb than flight No. 6, unsupercharged, with the Roots supercharger installed. This might be expected, since the turbo-supercharger installation added an appreciable amount of frontal area.

The air speed in climb and the high speed in level flight are shown in

Fig. 9. - During the tests with the turbo supercharger, flights were made at the air speeds which were found best with the Roots supercharger; but these air speeds did not give the best rate of climb, particularly for the higher altitudes. For the lower altitudes, the difference in air speed shown for flights Nos. 1 and 4 is without any particular significance, as the air speed giving the best rate of climb is much less critical for these altitudes. At the higher altitudes, it will be noted that the air speed giving the best rate of climb with the turbo supercharger increases rapidly. All turbo-supercharged flights showed this characteristic.

The curves of high speed in level flight, also shown in Fig. 9, were drawn from the best data obtained in many flights. There were not enough points to locate the curves exactly, but it was established that the speed in level flight was greater when using the turbo supercharger and that the difference increased with increase in altitude. At 21,000 ft. the high-speed performance was 122 m.p.h. for the Roots and 142 m.p.h. for the turbo-centrifugal type. The high-speed unsupercharged performance was practically the same with both supercharger installations. The high-speed performance obtained with the turbo-cen-

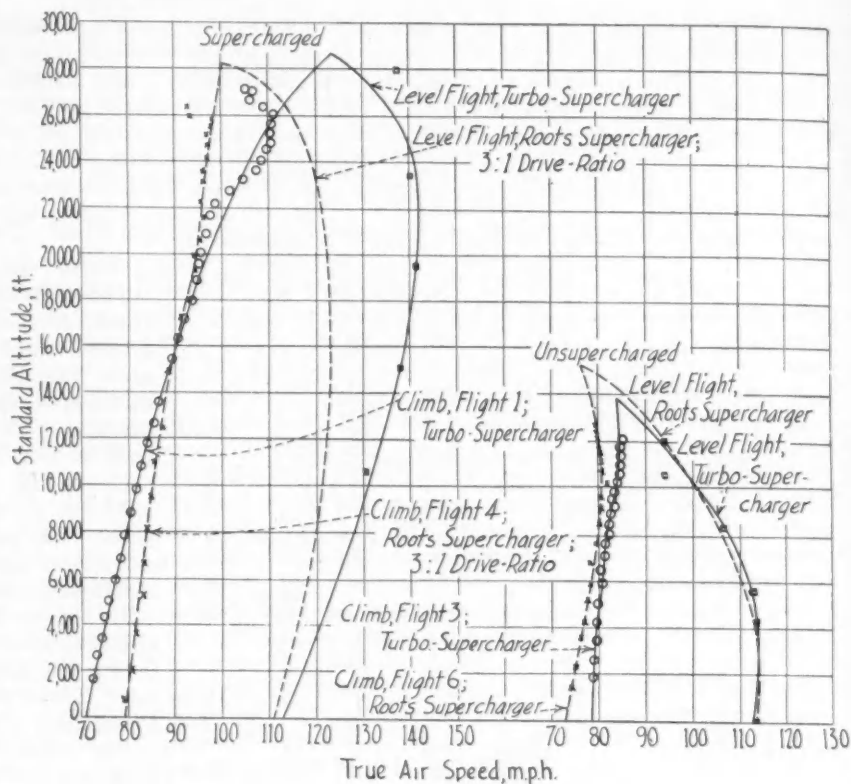


FIG. 9—AIR SPEED IN CLIMB AND IN LEVEL FLIGHT

Data Obtained with the Turbo Supercharger and with the Roots-Type Supercharger Using a 3:1 Drive-Gear Ratio; and also Unsupercharged but with a Supercharger Installed

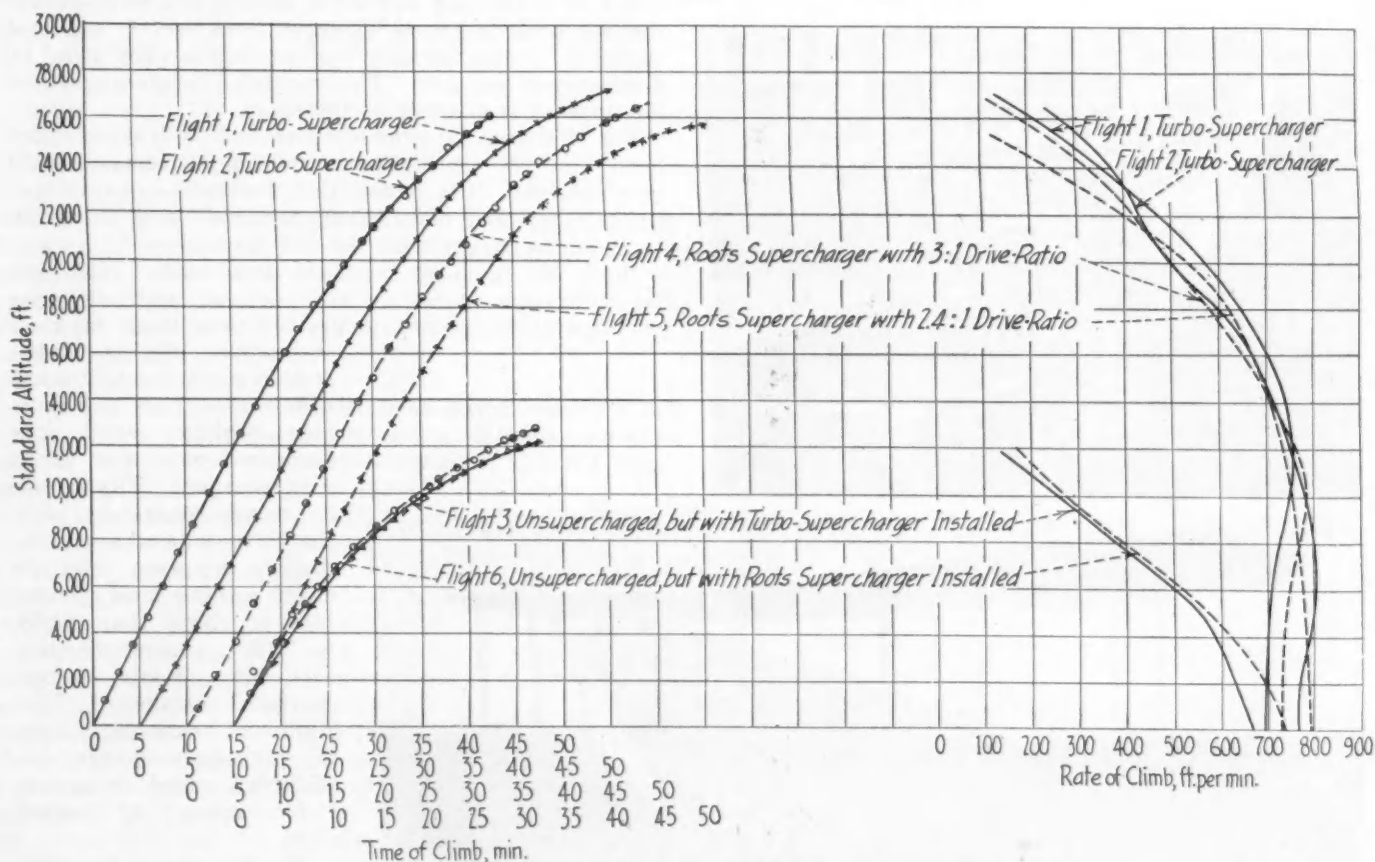


FIG. 8—CLIMB PERFORMANCE OF A DH-4M2 AIRPLANE

Data Obtained with the Turbo Supercharger and with the Roots-Type Supercharger for Two-Gear Ratios; and also when Unsupercharged but with a Supercharger Installed

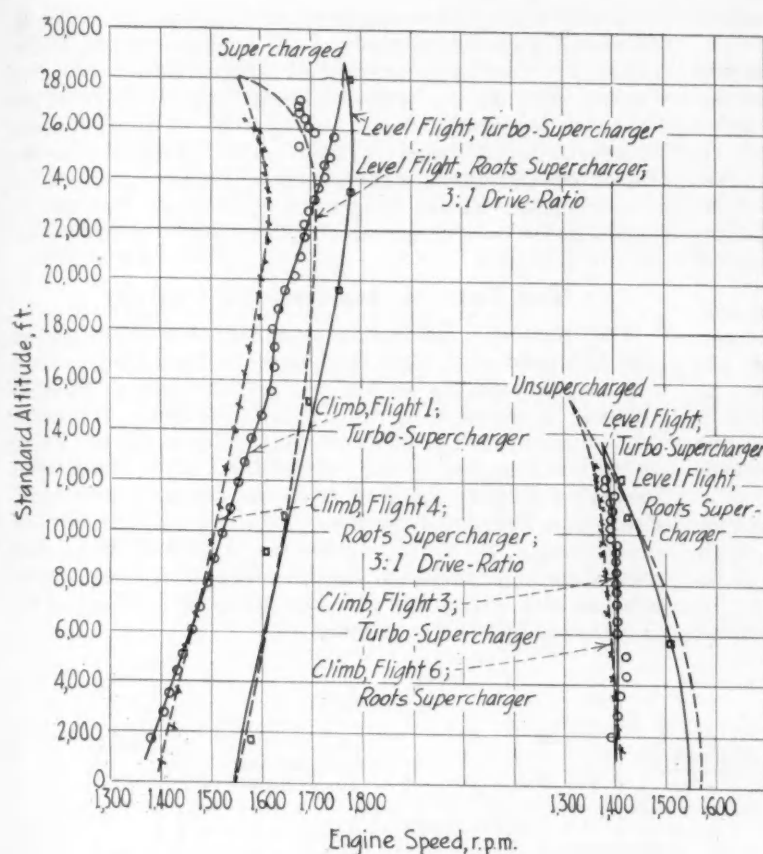


FIG. 10—ENGINE SPEED IN CLIMB AND IN LEVEL FLIGHT

Data Obtained with the Turbo Supercharger and with the Roots-Type Supercharger Using a 3:1 Drive-Gear Ratio; and also Unsupercharged but with a Supercharger Installed

trifugal supercharger, even with its increased frontal area, is a strong argument in favor of this type of supercharger for airplanes traveling at high altitudes.

The shape of the curves of engine speed in Fig. 10 follows very closely the shape of the air-speed curves in Fig. 9. The low engine-speeds at the ground were due to the use of a much larger propeller than is customary for unsupercharged work, to hold down the engine speed to less than 1800 r.p.m. at altitude on the supercharged flights. The comparative engine power in climb is shown by the curves in Fig. 11. The difference in engine power at altitude was due to the difference in engine speed as well as to the difference in power that each supercharger cost the engine. The acceleration at high altitudes of the engine equipped with the turbo supercharger was very sluggish; however, the turbo-centrifugal supercharger gave a greater improvement in all-round performance than did the Roots supercharger.

Effect of Supercharger Capacity on Performance

In the selection of a supercharger for use on an airplane designed to meet definite performance-requirements, the question arises whether it is advisable to choose a supercharger of sufficient capacity to maintain sea-level pressure to the maximum useful altitude or to choose one of smaller capacity that requires less power. The selection of the best supercharger-capacity depends largely upon the way in which the type of supercharger in question affects the engine power, the percentage of engine power required by the supercharger, and the kind

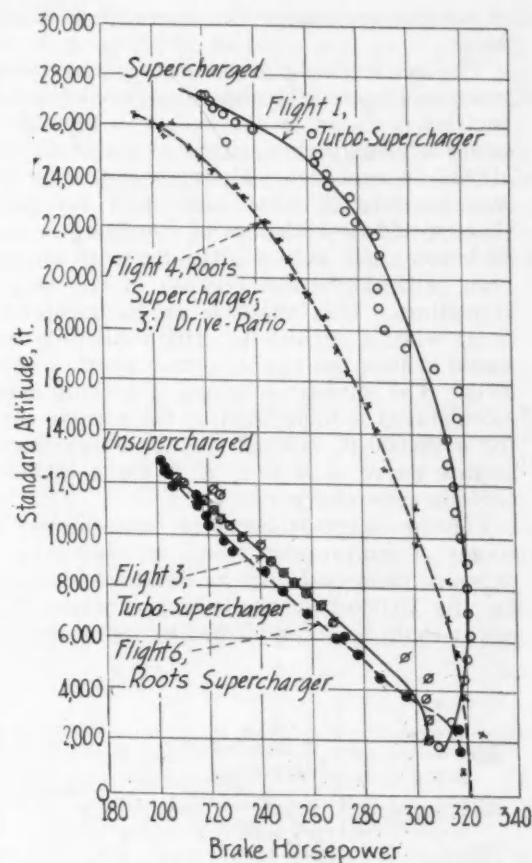


FIG. 11—POWER DELIVERED IN CLIMB

Data Obtained with the Turbo Supercharger and with the Roots-Type Supercharger Using a 3:1 Drive-Gear Ratio; and also Unsupercharged but with a Supercharger Installed

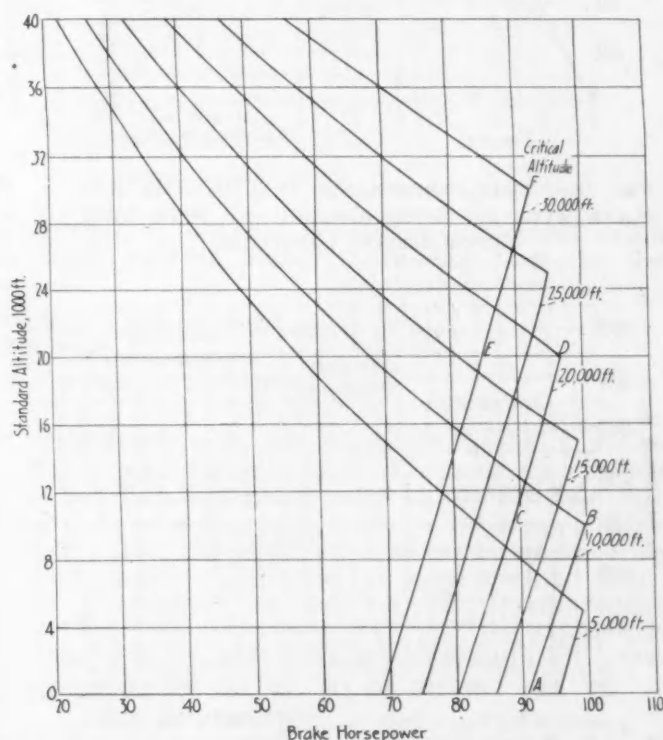


FIG. 12—NET ENGINE POWER AT ALTITUDES FROM 0 TO 40,000 FT.

Data Obtained when Supercharging a 100-Hp. Engine with Geared Centrifugal Superchargers of Six Different Capacities

of service for which the supercharged engine will be used.

The net engine power developed by a 100-hp. engine when equipped with superchargers of six different capacities is shown by the curves in Fig. 12. Although a cooler of sufficient capacity to maintain at the critical altitude a carburetor air-temperature of 50 deg. fahr., was assumed to have been used for each condition, there would nevertheless be considerable heating of the carburetor air at low altitudes with superchargers of high critical-altitude, because of the large amount of throttling. This increase in carburetor-air temperature, with a 20,000-ft. critical-altitude supercharger, would reduce the engine power about 7 per cent at sea level. The advantage of using a compressor of one or more stages is illustrated by the serrate curve *A B C D* for a 20,000-ft. critical-altitude supercharger, and the serrate curve *A B C D E F* for a 30,000-ft. critical-altitude supercharger.

For the 30,000-ft.-capacity supercharger at least two stages of compression would be necessary, as the high pressure-ratio could not be obtained in one stage, while for the 20,000-ft.-capacity supercharger the saving in power could be accomplished by using one stage and in-

creasing the rotative speed at the higher altitudes by means of a gearshift between the engine and the supercharger. The large amount of engine power required at low altitudes by a geared centrifugal supercharger is a serious disadvantage. This type of supercharger compares unfavorably in this respect with either the Roots or the turbo supercharger, because neither of these requires at sea level more than 2 per cent of the total engine power, nor do they heat the carburetor air at low altitudes.

Test Data on Supercharger Capacity

The National Advisory Committee for Aeronautics also has conducted tests to determine the effects of supercharger capacity on the performance of a DH-4M2 airplane powered with a Liberty-12 engine. A Roots-type supercharger of 0.382-cu. ft. displacement per revolution was mounted at the rear of the engine and driven through a flexible coupling from the engine crankshaft. Four supercharger capacities, obtained by driving the supercharger at 1.615, 1.957, 2.400 and 3.000 times engine speed, enabled the maintenance of sea-level pressure at the carburetor to altitudes of 7000, 11,500, 17,000 and 22,000 ft., respectively.

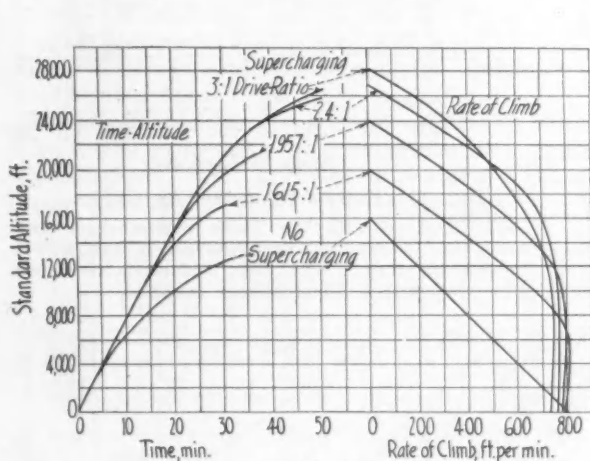


FIG. 13—CLIMB PERFORMANCE OF A DH-4M2 AIRPLANE WITH NO SUPERCHARGING AND WITH FOUR SUPERCHARGING CAPACITIES

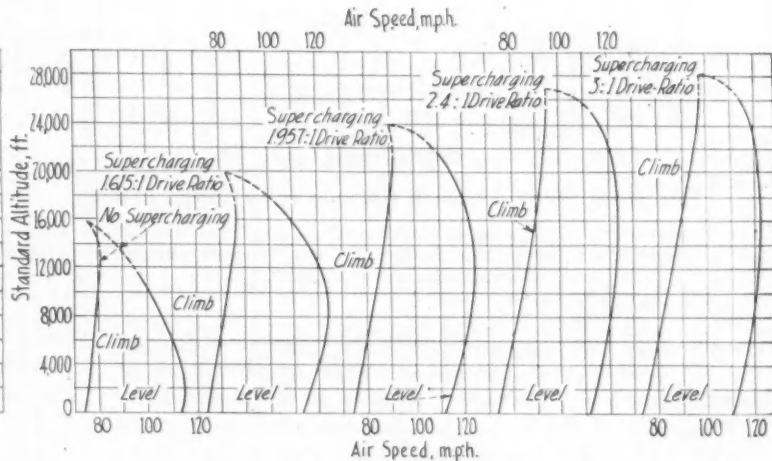


FIG. 14—AIR SPEEDS OF A DH-4M2 AIRPLANE IN CLIMB AND IN LEVEL FLIGHT WITH NO SUPERCHARGING AND WITH FOUR SUPERCHARGING CAPACITIES

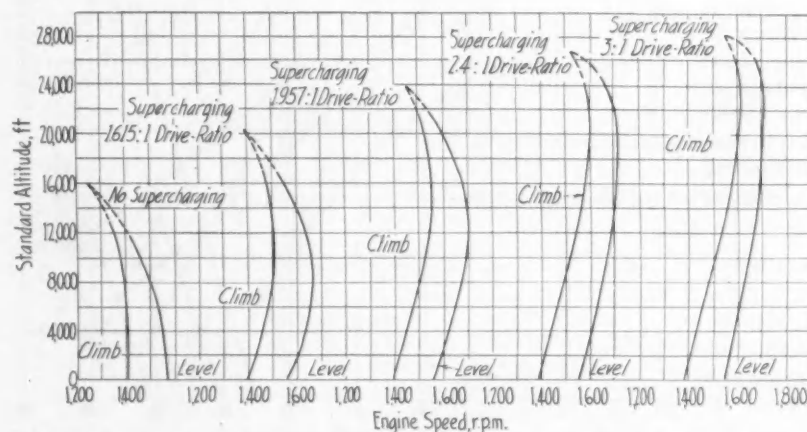


FIG. 15—ENGINE SPEEDS OF A DH-4M2 AIRPLANE IN CLIMB AND IN LEVEL FLIGHT WITH NO SUPERCHARGING AND WITH FOUR SUPERCHARGING CAPACITIES

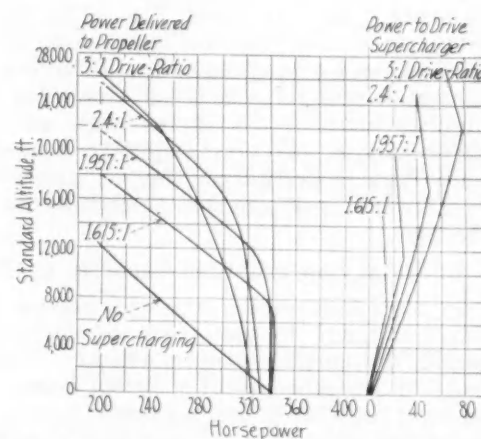


FIG. 16—POWER DELIVERED BY THE ENGINE TO THE PROPELLER, AND POWER REQUIRED TO DRIVE THE SUPERCHARGER DURING CLIMB

Fig. 13 shows the time-of-climb and the rate-of-climb curves for these tests. The curves show that there would be very little increase in ceiling and in high-altitude performance if the drive ratio were increased beyond 3:1. The trend of the rate-of-climb curves shows that further increase in supercharger capacity would considerably impair the airplane performance near the critical altitude. The loss in performance at the low altitudes, even with the supercharger of high critical-altitude, is small.

tain the best performance with each capacity would have required a propeller suitable for each capacity. The large amount of work involved in designing, constructing and calibrating these propellers prohibited the use of this method.

The power delivered to the propeller and the power required to drive the supercharger are shown by the curves in Fig. 16. Like the rate-of-climb curves, they show that it would not be advisable to increase the supercharger-drive gear-ratio beyond 3:1. The falling

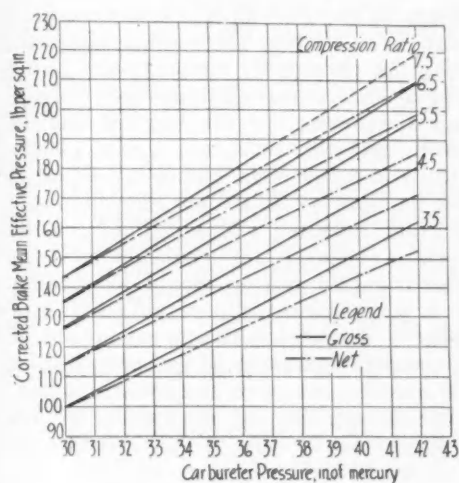


Fig. 17

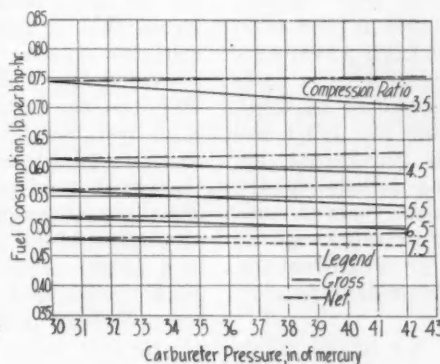


Fig. 18

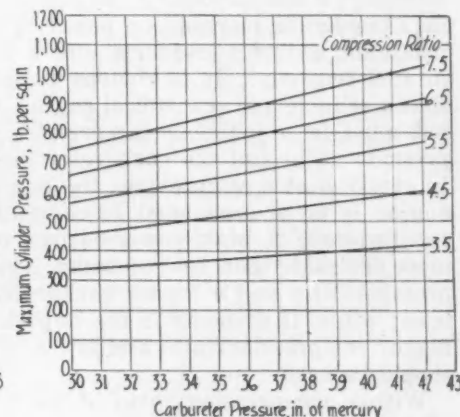


Fig. 19

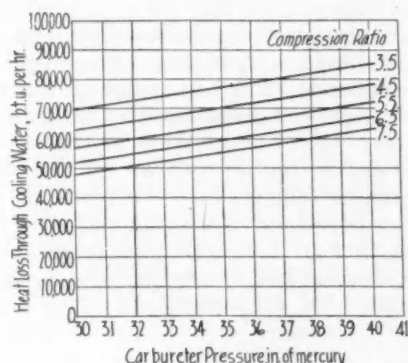


Fig. 20

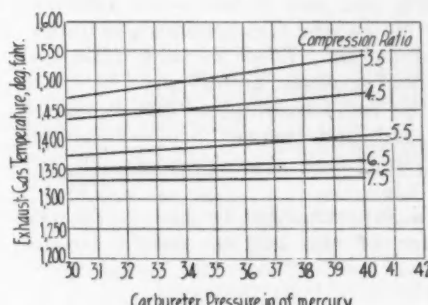


Fig. 21

FIG. 17—EFFECT OF BOOSTING, AT DIFFERENT COMPRESSION-RATIOS, ON BRAKE MEAN EFFECTIVE PRESSURE

FIG. 18—EFFECT OF BOOSTING, AT DIFFERENT COMPRESSION-RATIOS, ON FUEL CONSUMPTION

FIG. 19—EFFECT OF BOOSTING, AT DIFFERENT COMPRESSION-RATIOS, ON MAXIMUM CYLINDER-PRESSURES

FIG. 20—EFFECT OF BOOSTING, AT DIFFERENT COMPRESSION-RATIOS, ON HEAT LOSSES TO THE COOLING WATER

FIG. 21—EFFECT OF BOOSTING, AT DIFFERENT COMPRESSION-RATIOS, ON EXHAUST-GAS TEMPERATURES

The curves in Fig. 14 show the air speeds in climb and in level flight. It is interesting to note that, as the gear ratio was increased, the height to which sea-level high speed was maintained or bettered became a larger percentage of the height of operation of the airplane. The air-speed curves indicate that, up to the critical altitudes, the maximum speeds in level flight were very nearly the same for each supercharger capacity.

The engine speeds obtained in climb and level flight in these tests are shown in Fig. 15. As might be expected, these curves are very much like the air-speed curves. The propeller used was not suitable for engines of low critical-altitude. It had been designed particularly for supercharged work at high altitudes. To ob-

off in power below the critical altitude with the two higher supercharger capacities is partly accounted for by the increased power required to drive the supercharger, as is indicated by the second group of curves in Fig. 16. The supercharger power-curves show that, for the higher gear-ratios, the power required to drive the supercharger increases very rapidly with altitude and that, for the highest gear-ratio, the supercharger power is 24 per cent of the engine power at the critical altitude.

Effect of "Boosting" on Engine Performance

The Committee has recently conducted tests to determine the effect of boosting the carburetor pressure 10 in. of mercury at compression ratios of 3.5, 4.5, 5.5, 6.5

and 7.5:1 on the power, maximum cylinder-pressure, fuel consumption and other engine-performance characteristics. The N. A. C. A. universal test-engine was used in this investigation. It has a variable compression, rendering it particularly suitable for these tests. Benzol was used as a fuel for all conditions, so as to eliminate the effect of detonation.

The curves in Figs. 17, 18 and 19 show the effect of boosting on power, fuel consumption and maximum cylinder-pressures, respectively. They show that boosting the carbureter pressure results in a large increase in power, a comparatively small increase in maximum cylinder-pressures and a slight improvement in fuel economy; while increasing the compression ratio results in a moderate increase in power, a large increase in maximum cylinder-pressures and a large improvement in fuel economy. It is obvious from this information that a reliable and economical engine of high power-output must be a judicious compromise between the compression ratio and the carbureter pressure to be used. In arriving at a compromise, the purpose for which the engine is to be used must be carefully considered; as, for instance, if high power-output and reliability are more desirable than fuel economy, a slightly lower compression-ratio and a higher carbureter-pressure can be used; while, if economy is the important consideration, higher compression-ratio and lower carbureter-pressure should be used.

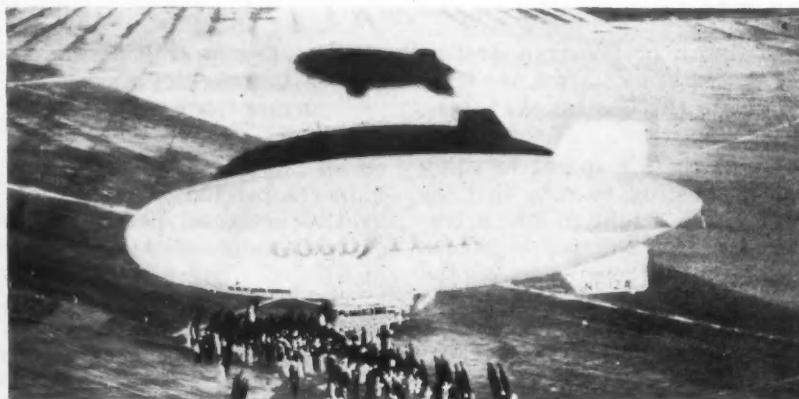
With a compression ratio of 5.5:1, the brake mean effective pressure is 126.5 lb. per sq. in. and the maximum cylinder-pressure is 562 lb. per sq. in. With a 4.5:1 compression-ratio and a 10-in.-of-mercury boost in carbureter pressure, the net brake mean effective pressure is 162 lb. per sq. in. and the maximum cylinder-pressure is 580 lb. per sq. in. There is very little difference in the mechanical stresses, as indicated by these maximum pressures; the fuel consumption has increased approximately 7 per cent and the net brake mean effective pressure has increased approximately 30 per cent.

To justify adding a supercharger to an engine, the weight per horsepower of the engine should be de-

creased. On water-cooled engines the addition of a supercharger that will increase the carbureter pressure 10 in. of mercury will reduce the weight-horsepower ratio of an engine of 400 hp. approximately 0.75 lb., while on air-cooled engines the reduction will be less than 0.50 lb. In this connection it may be well to state that the reduction in weight-horsepower ratio that can be obtained is considerably greater on engines ranging from 100 to 400 hp. than on engines of higher power.

The effect of boosting on heat losses to the cooling water and on the exhaust-gas temperatures is shown by the curves in Figs. 20 and 21. These tests show that the quantity of heat carried off by the cooling water increases directly with the carbureter pressure and is not appreciably affected by the compression ratio only insofar as determining the losses for the normal engine. From this it follows that the increase in size of the radiator will be the same for each compression ratio, provided the same amount of supercharging is used; however, the percentage increase will be higher for the high compression-ratio, because the radiator used on the normal high-compression engine would be smaller than that used on a normal low-compression engine of the same power-output. Increasing the power output of an engine of 3.5:1 compression-ratio 50 per cent results in a 20-per cent increase in losses to the cooling water, while increasing the horsepower of an engine of 7.5 compression-ratio 50 per cent results in an increase of 34 per cent in the losses to the cooling water.

It is interesting to note that boosting at high compression-ratios has very little effect on the exhaust-gas temperatures, while boosting at low compression-ratios results in a definite increase in the exhaust-gas temperatures. The advantage of supercharging an engine of high compression-ratio is apparent, when one considers that the intensity of the heat is more detrimental to engine reliability than the quantity of heat. From an exhaust-temperature viewpoint, as well as from a power viewpoint, one can safely say that the supercharging of engines of low compression-ratio is impractical. It is desirable that an engine have a compression ratio of at least 4.5:1 for supercharging.



The Economics of Seadrome-System Ocean Airways

Discussion of Edward R. Armstrong's Annual Meeting Paper¹

HEREIN the inventor and designer of the seadrome analyzes the possibilities of commercial operation of transoceanic air-lane service in general and with special reference to transatlantic operation. He shows the impracticability of carrying a payload on a non-stop flight of 1800 miles or more now required between lands on the Great Circle route or the route from America to Europe by way of Bermuda and the Azores Islands. Continental and intercontinental airways now in operation are successful only because the flight distance without refueling rarely exceeds 400 miles.

Ocean flying must be safe as well as profitable. Weather conditions present the greatest hazard in aviation, whether over land or sea; and danger in long over-water flights is inherent because of the distance that must be traversed without refueling and without engine inspection, weather reports or any of the other services that make overland airplane services commonplace, reliable and safe.

Establishment of safe and profitable transatlantic airplane operation is shown to be feasible only if floating landing and service stations are provided at intervals of approximately 350 miles along the route. The seadrome was designed to serve as such a station and every detail of it has been worked out on an engineering basis with the cooperation of leading marine architects and shipbuilding, structural and aeronautic engineers. The major engineering and manufacturing companies in the United States have been associated in the development. Theoretical calculations have been supported by model and small-scale tests. The structural features are illustrated and described, and methods of fabrication, assembling, towing to location and anchoring explained.

The projected route contemplates eight such seadromes located in a direct line from a point midway between Halifax, Nova Scotia, and Bermuda, where

the first seadrome will be located, and Flores Island in the Azores, thence on a line to Plymouth, England, and/or Brest, France.

Estimates of the cost of establishing and operating such a route and of revenue to be derived are given.

The author concludes his paper with an interesting discussion of the legal aspects of the project, including possible international complications, and shows that authoritative opinion holds that the seadromes will be private property subject to protection by the American Government.

Discussers compliment the author for the great thoroughness of his work, and much of the comment relates to comparative possibilities of lighter-than-air ships and seadrome-operated airplanes in transoceanic service. Answering an inquiry, the author describes the means for maintaining uniform tension in the anchoring cable. The seadrome-airway route selected, although longer in miles than the Great Circle route, is said to be the shortest for flying service because of the better meteorological conditions that prevail.

Questions of maximum wind-velocity, fog frequency and taking off and landing under adverse conditions are raised and answered. Inquiry is made as to the effect of a stern wind blowing counter to an ocean current and the possibility of the seadrome overrunning and fouling the anchoring buoy and cable; also regarding the lifting effect of a side wind under the deck if the seadrome is keeled to the extent of $2\frac{1}{2}$ deg. by a counter ocean-current. The designer states that the stability will not be affected by high winds, that the seadrome will drift up to the anchorage buoy and then swing around it in a period of about 40 min.; that it will line up into the wind under all expected wind conditions, and that weather conditions to be anticipated at any seadrome can be very definitely forecast.

CHAIRMAN C. B. FRITSCHER:—According to reliable statistics, 40 attempts have been made to date to fly the North Atlantic, non-stop, by airplane. Of these, 15 have been successful; the other 25 have been failures. Many lives have been lost, and payload has always equaled zero. Our friends who have specialized in airplane design tell us that airplanes do not increase in efficiency with size. The yardstick, the number of pounds of useful or disposable load per horsepower,

used by our engineering friends indicates that the most efficient plane today is able to lift off the ground only about 11 lb. of useful load per horsepower.

Dr. Dornier, in Germany, built a large flying-boat of 57 tons gross lift, called the Do-X, and according to his figures its useful load per horsepower is less than 10 lb., indicating that it is less efficient than an ordinary single-engine airplane of the cabin type that is common in this Country and less efficient than the ordinary tri-motored airplane. Evidently something else, something new, must be done to span the Atlantic commercially.

I have long believed and have had implicit faith that the Divine Creator did not reveal His secrets of

¹ Published in the S.A.E. JOURNAL, February, 1931, p. 151. The author is president and general manager of the Armstrong Seadrome Development Co., Inc., Wilmington, Del. For convenience of the reader, the abstract accompanying the paper is reprinted herewith, supplemented with a summary of the trend of the discussion.

* M.S.A.E.—President, Aircraft Development Corp., Detroit.

nature to man only in order that cities located on a continent, or islands close by, should be connected commercially by air-transport lines. I think that the big goal is to connect the continents; consequently, any engineering study directed to the solution of this gigantic problem of bringing Europe closer to the United States, and North America closer to Asia, is worthy of support and particularly worthy of serious consideration by those engaged in the engineering profession.

I have very recently learned that 18 years ago Mr. Armstrong was a consulting engineer engaged in automotive work. For the last 15 years he has been in charge of experimental mechanical engineering for the DuPont company, of Delaware, and until recently has divided his time between that position and the development of the Armstrong seadrome.

I am certain that Mr. Armstrong has presented the best documented engineering address I have ever heard. It is very gratifying and refreshing to come in contact with an engineer who approaches the transatlantic problem from a common-sense standpoint. In the first place, he has chosen the fair-weather route and tells us that an examination of the wind velocities as compared with the Great Circle route off Newfoundland indicates that, over the entire year, it really is the shorter route. I have never had any faith in the northern route. For centuries man has been acquainted with the fact that it is the stormiest place on the face of the globe. Just off Newfoundland the cold Arctic Stream comes down and meets the warm Gulf Stream, repelling it and producing a constant unbalanced condition in pressures and temperatures which makes it a breeding place for storms and almost perpetual fog.

It is also gratifying that Mr. Armstrong has brought to his assistance outside talent from related fields of scientific endeavor. Too many of our aeronautic engineers, particularly airplane designers, have misled the public with respect to the transoceanic capabilities of heavier-than-air craft. I recall one famous international designer who came over here in 1921. We gave him a luncheon in Detroit. He made a speech in which he said, "Within 10 years we will be flying 24-hr. non-stop New York to London." In 1925 he came back from Europe and made a speech in Washington. He said, "Within 10 years we will be flying 24-hr. non-stop New York to London." Last year he arrived from Europe again, was met at the steamship dock by newspaper reporters, and again gave his customary interview. Yet he never indicated how it is going to be done, nor has he demonstrated it mathematically before any engineering group.

Mr. Armstrong has recognized the short-range limitations of the airplane and has endeavored, and in a rather convincing way, to supply what the airplane lacks with respect to negotiating the Atlantic Ocean.

RALPH R. TEETOR³:—I should like to know the type of towing gear or anchor gear employed to maintain a tension of 5000 lb. on the structure, about how much take-up it would have and how it works.

³ M.S.A.E.—Vice-president in charge of engineering, Perfect Circle Co., Hagerstown, Ind.

⁴ Meteorological consultant, Armstrong Seadrome Development Corp., Inc., Wilmington, Del.

EDWARD R. ARMSTRONG:—The towing engine is electrical. It was designed by General Electric Co. engineers and operates through a series of stops adjusted for tension. The connecting cable is 1 in. in diameter, and on the end of the 3¼-in. main cable it is spliced into a stop which comes up against the towing-gear terminal. When the tension on that cable becomes less than 5000 lb., as registered by a spring-mechanism weighing device situated in the power area of the seadrome, this winding engine comes into action and, unless the tension increases, it will continue to pull in that slack until the anchorage buoy enters into the towing-gear connection, where it becomes part of the towing gear. The limits of tension required to actuate the engine are just a few hundred pounds one way or the other.

The engine really is an electrical brake of the fixed type. It is a modified arrangement of the equipment that the General Electric Co. has supplied for similar purposes. You may be familiar with the steam towing-gear with which many sea tugs and some of the Navy ships are equipped. This is simply an electrical adaptation of the same gear.

Meteorological Advantages of Chosen Route

CAPT. HUGH DUNCAN GRANT⁴:—Much of what I should like to say in detail has already been well covered by Mr. Armstrong in his interesting and comprehensive lecture tonight and, to some extent, by the Chairman. From the meteorological point of view, the seadrome crossing chosen by Mr. Armstrong, after exhaustive meteorological and hydrographic research, is the fair-weather route and, one might add, therefore the most practical of the several routes to be discussed

for flying over the North Atlantic. The northern route between Newfoundland and England is, of course, the shortest geographically; but, taking the varied meteorological factors into consideration, this passage is by no means the shortest; on the contrary, it is perhaps the longest of the transatlantic flying routes over which trails have been blazed. On the basis of an annual equation of weather conditions, the longest route in miles may readily develop into the shortest one in time. That is true in regard to the route between New York City or Bermuda and the Azores, which, in the latter case, represents a flying distance of approximately 2000 miles, but, because the average weather conditions are so much better there than

over the other routes, it is essentially shorter than the one which geographically is the shortest between Newfoundland and England.

In England one is continuously on the brink of impending meteorological changes owing to the ocean, on the one hand, and the Continent, on the other hand. In America the great continental blend of weather is carried out over the ocean eastward for 100 or 200 miles. Consequently there is a very rapid formation of coast-wise fog and, owing to low temperatures, of ice formation at flying levels. During the greater part of the year the fog extends into the cyclonic-frequency area in the middle of the Atlantic, where, owing to the confluence of the Gulf Stream with the cold air from Greenland and Labrador, one finds a cyclonic frequency which is notoriously dangerous for aircraft of



C. B. FRITSCHÉ

all types and kinds flying non-stop between Europe and America.

The route as finally determined upon by the seadrome corporation undoubtedly is the safest and, in many ways, economically in particular, the most reassuring and practical. From the weather standpoint, therefore, one need only add that the company has weighed exhaustively and, to my mind, wisely, the many factors warranting selection of the southern route.

Maximum Winds and Dirigible Possibilities

W. N. GERHARDT^{*}:—Are there ever winds at the seadrome locations which might be greater than would be safe for the landing of a seaplane? Also, would it be practical to use the seadromes as anchoring bases for dirigibles?

MR. ARMSTRONG:—The maximum wind velocity, as estimated by the United States Weather Bureau officials, is 70 m.p.h. at some of the station locations. I may say, as qualifying that, that 70 real m.p.h. represents about 90 m.p.h. on the old-fashioned anemometer. The four-cup Robinson anemometer is very much in error in the upper ranges. The correct reading for maximum velocity is, as I say, 70 m.p.h., and that is very infrequently experienced. To operate airplanes and land and take off at such velocities would not be very practical even at land airports, although it has been done. The difficulties, in my opinion and in the opinion of fliers, would be less on the ocean route because of the lack of turbulence in these high-speed winds, as there are no obstructions in the open ocean. If there is a 70-m.p.h. wind, that will be from a storm origin which is traveling about 20 m.p.h. over the ocean. A seadrome station would very quickly be cleared of a storm of that velocity. Presumably it would be quite feasible for an aircraft that was approaching in a wind of any such velocity either to go back to the other seadrome or remain in the air until landing would be safe. The excess fuel would enable it to do that.

Landings have been made on airplane carriers when the velocity of the wind plus that of the ship was such that the men on the deck seized the wings and the landing-gear and pulled the airplane down to the deck. Of course, that is an extreme condition of operation.

The question of whether aerial masts will be erected for dirigibles will depend entirely on whether dirigibles are used for ocean service. As I see the matter, dirigibles, to be reasonably fast, must be large. When they are large, they have a great capacity and are costly to operate, and it will be difficult to give the frequency of service which I described in my calculations as necessary to a successful ocean airport. The system I visualize for that purpose may be used when the traffic over the Atlantic is developed by the airplane system to the extent that hundreds of passengers would leave in one group every day.

Relative Aircraft Speed and Cost

The great handicap, to my mind, is the fact that, given a commercially successful airplane operation, the cruising speeds will increase quickly in a few years,

say in less than ten years, which seems to be a favorite period with aviation forecasters. I would say they will increase to practical speeds around 180 or 200 m.p.h., and I think that even the proponents of dirigibles will admit that they have a long way to go to arrive at any such speeds with airships.

Incidentally, the capital cost per passenger of an airplane as compared with that of a dirigible equipped for transatlantic work would be about one-tenth, assuming that an airship to carry 100 passengers costs \$5,000,000 and an airplane to carry 50 passengers costs \$200,000. These are rough figures, but they show that the capital-cost element is very much in favor of the airplane as a carrier; and, when the investment is carried over a long period of depreciation and amortization at low rates of insurance and of maintenance, the investment in airplanes to give equivalent service is relatively small.

It is interesting to know that, with only one return trip per day over the seadrome route to Europe, carrying 400 lb. of air mail at \$4 per lb., the total investment of \$33,000,000 or \$34,000,000 can be taken care of and such an operation will actually pay a return. It is foolish, of course, to expect that only one return trip per day would be made by a small amphibian.

CHAIRMAN FRITSCH:—The proponents of dirigibles do not believe that there will be any necessity for landing in mid-ocean; hence, why a mooring mast on a seadrome? In the second place, the fact is that, of the 601 persons who have flown across the North Atlantic non-stop to date, 564, or 94 per cent, have flown by dirigible. Eleven attempts have been made to fly the North Atlantic by dirigible, and all 11 have been successful and no lives have been lost. None of these flights, however, was made with an airship of sufficient size to be commercially practical on such a long route, although considerable payload has been carried.

With respect to speed, the dirigible, flying non-stop, will avoid the delay of having to land at a seadrome to refuel, which will compensate to some extent for the superior speed of the airplane. Those who have had the privilege of being associated with the metalclad type of airship—I am sure Mr. Upson will bear me out in this—foresee the easy attainment within the next decade of speeds up to 125 m.p.h. This is possible because the pressure behind the skin assures the structural integrity that will sustain the aerodynamic load involved at such high speed. As regards the metalclad design, the problems are now simple. The attainment of this higher speed is awaiting engines of high horsepower with improved thermal efficiency and better fuel efficiency.

Payload Should Increase with Aerodynamic Efficiency

PROFESSOR GERHARDT:—My second question was not asked with the intention of precipitating a discussion of the relative merits of heavier and lighter-than-air craft, but perhaps it is inevitable that it should come up, as the seadrome system is a radical attempt at an engineering solution of the problem raised by the fundamental defects of the airplane as a load carrier. Indeed, the boldness of its inventor and his thoroughness in the development excite admiration.



EDWARD R. ARMSTRONG

^{*} Professor of aeronautics, College of the City of Detroit, Detroit.

In still further support of the airplane side of the question, one might go so far as to suggest that the fundamental assumption upon which Mr. Armstrong bases his argument and actual spacing of the seadromes may some day be proved pessimistic, as certain aerostuctural and powerplant combinations theoretically proving great gains are as yet not applied. One hesitates to make this statement after the very apt remarks by Mr. Armstrong that airplane designers' paper improvements many times fail to materialize, and I make it, not so much because of a definite knowledge of methods of improvement as because we see our assumptions in all fields so frequently invalidated by unexpected discoveries. Even though some radical load-carrying improvements may arrive some day, it seems to me that the frequency of seadromes should be maintained and the gains put into payload and not into fuel for greater hops. The effectiveness of air transport as a new social instrument in bringing about those international economic and political changes which our prophets have been predicting seems to me to depend upon carrying a greater volume of passenger and mail traffic than can be carried by marine ships, as well as doing this at vastly greater speeds.

We must not forget, however, that the peculiar properties of the dirigible, which cause its useful load to increase with its size, keep it in the picture in spite of the vastly greater cost of fabrication, which requires the tying up in a single unit of an amount of capital that would be prohibitive to most operation ventures. Mr. Armstrong implies that it is impossible to predict now which type will ultimately give the better service, considered in the broadest sense. It is easy to see now, in any case, that the dirigible mast is not an immediate issue, but I still believe that its ultimate inclusion probably would be advantageous to both systems.

Effect of Counter Wind and Water Forces

RALPH UPSON*:—I am rather inclined to agree with what Mr. Armstrong implied, except that I would put it a little more strongly, in this way: That an airship of 200 m.p.h., or anywhere near it, will never be built, not because it is necessarily impossible, but because such speeds are so much more easily attained with the heavier-than-air type that there is no point in wasting effort on the lighter-than-air craft in that speed range. When we get down around 100 m.p.h. the situation is quite different. However, if and when Mr. Armstrong's seadromes are actually established on any given route, I think he will have a development that would be rather hard to beat, for that particular route. The lighter-than-air ship will always have its uses in other fields.

The subject of this paper, I am sure, has intrigued almost everyone here as it has me; in fact, I have been interested in the project for many years, as much as I have been able to follow it from a distance. Certainly, if fundamental soundness of conception, ingenuity of design and thoroughness in execution mean anything, the Armstrong plan ought to succeed. I can foresee

many new problems, particularly concerned with the type of flying equipment to take the greatest advantage of the facilities provided by the seadrome system, but I am confident that such problems can be worked out.

It is easy, in the case of such a big undertaking, for one who is not intimately acquainted with it to offer numerous objections, but by the same token it should be rather easy, and apparently has been quite easy for Mr. Armstrong, to answer most of them. However, let us see if he can answer this hypothetical question:

Suppose that the current of the Gulf Stream at the worst is only 2 m.p.h. Other things being equal, an air speed of roughly 30 times the water speed is needed to give equivalent pressure and drag forces; so a wind that would be equivalent to an ocean current of 2 m.p.h. would be, roughly, on the order of 60 m.p.h., which is close to the maximum that has been mentioned for that route.

Now, suppose that the particular seadrome anchored in this supposed 2-m.p.h. current were subjected to a gradually increasing wind from the stern end. As long as the wind was relatively small, the ocean current would determine the position of the seadrome with respect to anchorage, but suppose that this tail wind increased to 50 or 60 m.p.h. when presumably it would approximately equal the effect of the ocean current; might it not thereby produce, if it continued to increase, a condition of instability reversing the direction, thereby possibly fouling the anchorage, and cause interference forces as between the wind and water current, particularly when they were both striking the seadrome laterally, in which case the carefully streamlined supports would no longer be streamline, but would catch both wind and water forces transversely? Also, the tremendous area of the platform, if tilted even at so seemingly small an angle as 2.5 deg., as has already been mentioned, would offer very large aerodynamic life on the surface that again might cause serious disturbances in what would otherwise be very satisfactory equilibrium.



RALPH H. UPSON

Seadrome Will Line up into Wind

MR. ARMSTRONG:—The water currents on the route in the Gulf Stream and in the locations which are adjacent to it reach a maximum at the first station of 1.5 knots. In other parts of the stream they may occasionally go to about 3 knots and combine with currents brought about by high-velocity winds. In addition to the normal surface currents generated by winds, there are submarine currents which are brought about by differences in water temperature. Those currents extend to depths certainly over 2000 fathoms and apparently reach somewhat beyond that, but do not go into the great deeps. The currents in the deep portions reach a maximum of about $\frac{1}{2}$ knot, and during a day swing almost completely around the horizon.

The water resistance of a seadrome structure is symmetrical about the structure; that is, the seadrome has no tendency to place itself in the current in one direction rather than another, because the prime members are circular in section and therefore offer the same resistance in all directions. At low current-speeds

* M.S.A.E.—Aeronautical engineer, Dearborn, Mich.

all resistance, in the sizes we are dealing with here, is surface or skin friction, and turbulence, which follows practically the same law, increases with the square of the velocity.

The resistance, based on factors which are available, of the under-water portion of the seadrome is about 35,000 lb. in a $1\frac{1}{2}$ -knot current, and that force, of course, is unidirectional. A small wind-velocity acting on the fin area will swing the seadrome at an angle to the anchoring gear, it is true, but will line the seadrome up into the wind in spite of the fact that the connection to the anchorage buoy has a considerable yaw. Eventually it may trail out quite straight, but it may continue to be in a yaw position with regard to the water current although it is lined up to the wind.

The effectiveness of currents much greater than 2 to 3 m.p.h. was determined on the large-scale model, because, relatively, the currents greatly exceeded such speed. We have had experience with currents up to 7 or 8 knots, that introduced some wave-making resistance and were way beyond the scale to which the full-size structure would be subjected.

Stability Not Affected by Wind

In regard to the possibility of the wind getting under the deck when it is inclined, and the resulting aerodynamic forces bringing about serious disturbance of stability; the righting couple due to a change in the center of buoyancy and to the angle of heel, which brings about a righting pressure because of the low center of gravity, is about 20 times that caused by the disturbing influences. In other words, the lifting effect of the structure as an inclined plane will never have a chance to function, because the water forces are predominately greater; so, on the basis of real experiments which were controlled quantitatively, the seadrome will line up into the wind under all conditions which the wind velocity is expected to produce. That is an engineering factor; that is, we can use larger rudder areas, so that the seadrome would trail at a lower wind-velocity than 15 to 18 m.p.h. Pilots, airplane designers and others whom we have consulted on that phase believe that a wind up to a velocity of 25 m.p.h., as long as the seadrome is generally in the direction of the wind, would not affect landing and take-off, and that at higher velocity they would land directly into the wind.

MR. UPSON:—One point that you did not touch on is the particular case, which is imaginary perhaps, of a rather considerable increase in the wind from a position directly astern of the seadrome with reference primarily to water currents.

MR. ARMSTRONG:—In that condition, and we have had it experimentally, with the current effects and the wind effects opposite and parallel, the seadrome drifts up on the anchorage buoy and pushes it a certain distance, then starts to swing around. The swing period of a full-size seadrome is about 40 min.; that is, a considerable period is needed for it to position itself into that condition. The movement is so slow because the seadrome is a 50,000-ton structure and the forces of the currents and winds are not sufficient to move it rapidly. In the event of a sudden change of wind, if it was blowing with a velocity of 40 to 50 m.p.h., a pilot would have to wait until the seadrome would trail into the wind. You must keep in mind that the weather

and the wind conditions are very minutely known, not only for the immediate locality of the seadrome, but for the flying route as a whole. I believe that forecasting will be so simple and reliable that the dispatcher will determine whether or not flying is to be done and would know the hazard that would be introduced by that operation.

Fog Frequency and Fog Landing

H. C. DICKINSON¹:—Is it contemplated that the frequency of fog on the route selected will be so low as to cause no serious inconvenience in travel? And, if fog landings are likely to be required, is any provision to be made whereby fog landings can be made?

MR. ARMSTRONG:—The route has been selected primarily to avoid fog hazard as much as possible. According to the pilot charts of the North Atlantic, whereas fog prevails 30 or 40 per cent of the time on the Newfoundland route, the first station on the Bermuda-Azores route would have about 5 per cent. The next station is apparently outside the 5-per cent fog line, which is the minimum that is recorded on the charts; and, from there to the Azores and beyond, no fog is recorded. In certain months, on the easterly side of the ocean, quite dense fog occurs in the English Channel and territory adjacent thereto. One reason that the route is planned to operate to Brest, France, and under some conditions to Bordeaux, rather than to Brest, is to avoid the fog that comes pouring out in the Channel and which is produced by the Arctic streams coming down and swinging around the European coast.

It is not contemplated that fog landings will ordinarily be made. I see no reason why the radio-beam system that is being developed, especially by the Bureau of Standards, or the infra-red-ray development which is also being worked out, should not make landing on the seadromes possible in fog. An infra-red-screen arrangement should make the fog transparent for all practical purposes. As a practical hindrance the amount of fog will be, I suppose, possibly 20 per cent of that experienced on the least foggy route of our transcontinental flying, and that is not enough of a hazard or a sufficient influence to seriously affect schedules.

Of course, fog records on the charts indicate that during part of a particular day fog was encountered in a certain part of the ocean. Most of those fogs may be morning fogs and, according to the schedules, the pilot might not experience one-tenth of that particular fog as recorded. All in all, I should say that there would be no reason that we should not expect 95-per cent operation on the basis of schedules. As there is no way of abandoning a trip or going some other way and making the same time, we are not planning operation on the basis of, say, only 95 per cent of perfection; we figure that every trip that is delayed will be completed at a later date, and we are providing equipment sufficient to do that. If one starts for Europe and is held up, he cannot say, "If you don't hurry up I will take some other company's route or walk." He must wait until he can go on. From an operating point of view it is rather a nice situation. Incidentally, on the seadrome route there are no short-trippers. That in itself is a tremendous argument toward very rapid transportation.

Fields for Both Dirigibles and Airplanes

Touching for a moment on the aspect of dirigible transatlantic service, nobody knows what the dirigible

¹ M.S.A.E.—Chief, heat and power division, Bureau of Standards, City of Washington.

development is going to be. Up to date it has been financed generally by governments, and it is going to take a great deal more money. I would say that easily several seadrome systems will be financed and developed before we get to the final answer.

The fact that would make the airplane possibly more suitable than the airship is that primarily we are to provide transportation, and the system that befits the needs of the traveling public will survive. That, of course, means on a dollars-and-cents basis and also frequency of service, safety and many of the other things that go to make up reliability. As neither a seadrome airway nor any dirigible airway exists, one man's opinion is as good as another's. I think it is foolish for any engineer to take the position that the dirigible has not a great future ahead of it. I hope that the dirigible people will be successful. But I am in the airplane business, and, predicating something on that, I believe that we have all we can do to look after that.

In the end, the system that is best adapted to the service will survive. Probably both types of craft will be used, but it is hard to foresee just what field will be most successfully filled by each. On the North Atlantic route, which will connect so many millions of people and on which frequency of service is demanded, I think speed will have a very important part in determining that. Over the Pacific Ocean and to outlying places such as the Philippines, I question very much whether a seadrome route would be justified until the dirigibles have built up a considerable volume of traffic. In that event we might want to get into that branch of the business.

CHAIRMAN FRITSCH:—I would like to insert into the record, to make it complete, a brief statement as to the funds spent to date on the development of the two types

of aircraft: the airplane and the dirigible. I recently have had occasion to investigate this subject and have found that the wartime expenditures of our Government on the airplane, plus the appropriations for the Army and the Navy since the war, plus the appropriations for air-mail subsidies, for the Bureau of Civil Aeronautics of the Department of Commerce and for the Weather Bureau Service, plus the \$800,000,000 or \$900,000,000 which the American public poured into aircraft ventures in 1928 and 1929 totals the stupendous sum of \$3,000,000,000 which has been spent on this mechanical infant in the last 20 years.

In contrast with this huge sum, careful examination of Government budgets indicates that only \$60,000,000 has been spent on airships and of this amount somewhat more than \$40,000,000 has been spent for the small, fabric non-rigid blimps and their operation, which we all recognize do not possess any commercial value. It would be interesting to speculate where the airplane and the dirigible, respectively, would be if these two figures were reversed. This is no criticism, however, of the Armstrong seadromes. Personally, I am in favor of spending more money on dirigibles and seadromes and less on airplanes. I might direct attention to the prophecy that history in the future may describe the airplane as the taxicab and the dirigible as the freight train of the air.

In closing, I should like to state that the patient research and study that Mr. Armstrong has given this subject over a long term of years is an excellent demonstration of the fact that invention does not spring full-grown from the minds of men. Careful research in adequately equipped laboratories, accompanied by elaborate experiments, is essential. Mr. Armstrong's presentation of this subject bears evidence of the type of research and experiment that breeds confidence.



Safety Aspects of Car Construction

Annual
Meeting
Paper

By Robbins B. Stoeckel¹

THE DEPARTMENT of a State having to do with highway safety is, first of all, the department which deals with the building of highways. In that department there are many expert adaptations of highway-safety engineering. I have seen highway-safety engineering grow in our own section of the Country in the last 15 years and have come to the conclusion that it is in danger of being overdone along some lines. The highway department marks the roads; it provides the signs that indicate the dangers which may be expected. Psychologically, however, if the highways are over-marked a certain amount of inattention to the signs is created; so I think that the marking should progress with that fully in mind and ought not to be as frequently and as completely done as it is now in some States.

The highway department is obliged to look forward and see that its markings are so placed that it is forewarned and forearmed if an accident case is taken into court and an attempt is made to prove that the department was at fault.

The next commission which has to do with highway safety is the police commission, meaning all the police in a State and all the enforcement provisions which are worked out by those police authorities. In a general way I think I can say that the enforcement of regulations is becoming much more reasonable and happy than it has ever been. It is taking into account the growing necessity of direction, realizing that discipline is not the whole thing but that direction is part of it. As that particular saving grace of the police gains in the attitude of police management all over the Country, we are

going to be a happier people, and I think we are going to drive better.

The next department concerned with highway safety is the motor-vehicle commission of the State. Its original function was to register motor-vehicles, and it did not do much else as to licensed operators. As traffic condi-

tions developed, however, the matter of highway safety began to come to us, first, because Connecticut is a small congested State in which the complications were practically all present at once. In a very short time, in common with all the motor-vehicle administrators in parts of the Country where the traffic problems are similar, we found that we had a safety problem wished over onto us. So the administrators have gradually become less and less tax gatherers and more and more concerned with the safety management of their sections.

In every State, where the emergencies and exigencies of modern traffic have brought about an insistent demand, the State motor-vehicle administrator, by whatever name he is designated, has gradually become the State's traffic-safety official. His registration records afford identification for whatever purposes needed. So, as early as 1917, when the complicated relationship between highways, the traffic thereon and motor-vehicle performance began

first to be realized, this official was the one upon whose doorstep this duty to enforce safety was placed. In some States records of motor-vehicle accidents and similar safety records on operators and owners were even then collected, and they have been kept up with increasing accuracy ever since. The other side of highway safety in practice, that which includes the operator-licensing system and its various applications of discipline by selection, suspension and revocation of opera-

Problems forced upon State administrators of motor-vehicle laws and regulations by the growing hazards of the highways are discussed in a friendly spirit of recognition of the efforts made by vehicle manufacturers to increase the safety of their product and of users to avoid accidents.

Cooperation of the manufacturers with the State motor-vehicle commissioners is urged and a suggestion is made that they consult with the authorities before introducing new mechanisms or devices that will affect the operation of vehicles.

Specific items considered are brakes, head-lamps, free-wheeling, fire hazard, safety glass, wind-shield wipers, horns, speed, and size and weight of motor-trucks and motorcoaches.

The tendency in laws and regulations is stated to be toward making them simpler and more general in application, placing on the manufacturer the obligation of making cars and equipment that will accomplish the desired result.

¹ Commissioner of Motor Vehicles, State of Connecticut, Hartford, Conn.

tors' licenses, need not be gone into here beyond stating that it has held the pace.

Laws Tend To Become More General

Safety laws and rules, in most cases expertly recommended by him, have been made and enforced as each such administrator has had increasingly more to do with highway safety. Again, by way of a remark, the trend of these is to become more simple, more inclusive and so general in their language and application that reasonable compliance with them can be insisted upon. Nowadays they all tend toward fixing responsibility on the individual and measurement of his performance by reason. Many of these rules and laws made for safety relate to the automobile as a machine and to its equipment.

Every administrator knows that he is not an engineer. He knows that he is not in any way going to be able to do a thing exactly; that he will have to take approximations and get away as happily as he can with the use of those means which are provided for him by the State for which he works, and very often they are inadequate. That is the case with us. We are getting into a situation where we realize that our laws have been too particularly made. They do not fit all the cases, and we can not adapt them; and that applies not only to the Department of Motor-Vehicles but to the other two departments as well. The administrator should bring before the legislature, as it goes into session, these broad adaptations which will make the laws fit all the necessary applications.

Among his other duties each administrator has been forced to become an educational specialist, one who instructs and warns and even in many cases actually foresees and prepares against highway accidents by advance educational publicity. This duty has proved—if that can be said about anything which he has done—successful, with the result that he now has, more than any other official, his own public from which groups and individuals come to his section for advice and counsel and which, to some slight extent at least, listens to him when he has anything to say. So he has duties far in excess of his original assignments. In some States he is now actually the traffic authority; in some others he is consulted; and in still others what he says and does has weight through publicity. He also has duties of performance; he must take on and apply safety measures from time to time, must work them out and get results.

Consequently, being charged with responsibilities as he is, and having learned by his own and others' experience, he is not likely to "go off the handle" about anything connected with his job. Assuming that car construction and maintenance are not as good as they might be made for safety, which assumption cannot possibly be proved at this time, a further safety duty confronts him. The administrator, through study of accident causes and by application of statistics, has long been convinced that fully 80 per cent of all automobile accidents are caused by failure or mistake on the part of an operator. The other 20 per cent he charges to pure accident, to highway defect (including lack of sufficient safety engineering), actual criminality and mechanical failure.

Car Imperfections Cause Few Accidents

Considered as a proximate cause alone, the automobile does not by its mechanical imperfections make many

accidents. But, on its history as a contributory cause, the story is far different. It probably is impossible to pin down any accurate fixed percentage of automobile accidents and charge them to mechanical failure as a proximate cause, but that such failure contributes to make accidents is undeniably true. It is important to note that, except in a small number of cases, such a failure is a contributory and not a proximate cause.

This is due, of course, to the extreme adaptability of the human being who is a factor in each situation. This is so great as to compensate in many, probably most, cases for the faults of poor performance by the machine. For example, many an operator unconsciously becomes accustomed to adjusting his capability to the lessening efficiency of his brakes, until he is driving, successfully in most cases, an automobile which might almost be said to be without brakes. He has "wilfully," in the scope of legal interpretation, let his safety factor in this respect diminish, until he is not fitted to cope with an emergency should he permit himself to become involved in one; but any accident under such circumstances, should one occur, cannot well be charged to mechanical failure.

It is cheerfully admitted that no State administrator can ever properly criticize car-safety construction as such, but there is no reason why every State cannot keep records of and criticize car performance from the angle of highway safety.

One more generality presents itself. On construction alone, leaving maintenance for future consideration, the fact seems to be that manufacturers, with few exceptions, have considered the administrator, if they have thought of him at all, as hostile. They realize that he knows comparatively nothing of their efforts and product; his duties are with the finished automobile. This attitude, so far as it still exists, is wrong, and, more than that, it is uneconomical and costly.

Should Tell Administrator of Design Changes

Granting that the administrator's official duties, ranging from the collection of taxes for building highways to the individual use of the highways by automobiles registered in his own and other States, require his carrying out sound policies relating to their existence, authorization and management, it follows that he should know all he can be told about them. He must be informed of essential changes in advance of the general public, because of the duties of education with which he is charged. He is called upon for all sorts of activities in connection with manufacturers' or dealers' problems and consequently needs to be kept fully posted. Usually his department is wide awake and approachable, so why not keep him posted on construction?

The fault is not all with the manufacturer by any means. State officials apparently have felt in the past that they must be "stand-offish" where an industry is concerned. This attitude must be forsaken forthwith, and the administrator must go out of his way to find out what he needs to know. Every argument that can be produced calls loudly for a better understanding between States and the great industry which produces automobiles.

Having now brought this subject down to the point where justification to do something about it seems to be established, the further decision is as to what to do.

Very recently, in beginning its study of car construction and maintenance, the Connecticut Department of Motor Vehicles made an inspection of passenger-cars

of various makes as to some of their safety features. One of these has to do with brakes. The common practice in many States has been to try to control brakes by law. Many motor-vehicle acts have been particularly drawn to make restrictions upon the construction of brake hook-ups.

After all, why should a State tell an industry how to do things which are primarily within the knowledge of the industry? As to brakes, why not say, "Automobile brakes must be adequate" and let it go at that? It is safe enough to conclude that, so far as design and construction go, competition and the sales argument will keep brakes efficient far beyond the point which safety requires. Should it ever happen that an idea gets out that any car has poor brakes or brakes which are hard to adjust and keep serviceable, the manufacturer will encounter an immediate increase in sales resistance and correct his product to whatever extent is necessary. In short, with only the simple rules and a few tests by which to determine adequacy, the making of brakes will take care of itself. Adequacy can readily be tested by a State; it is now done as a part of the enforcement program for proper maintenance.

With that proposition, and without taking up the subject of maintenance at this time, I think that we shall be content to stop in Connecticut, and that the industry may expect that we will offer a law which will be broad in its language and application and rely upon the manufacturers to make good brakes. I do not think that the determination by a State as to adequacy needs to worry the manufacturer so far as construction is concerned. As regards maintenance, a standard will have to be established for the brakes to measure up to in performance and usage.

Studying Causes of Fires in Cars

Another feature of study had to do with fires and the question whether wiring has anything to do with their causation. Only an extremely small number of statistics were available; in fact, these statistics, so far as Connecticut is concerned, cover only 47 passenger-cars, 16 commercial vehicles and 5 other types, or 68 in all. Such a small number makes it impossible to draw conclusions, but, on the basis of these particular fires, in each of which a car was destroyed, it appears that the former statement relative to proximate and contributory cause applies also to fires and that a fire usually results, not by reason of an inherent defect in the car, but because some accident or mischance has destroyed the safety factor in this respect. Fires generally are found to follow collisions or upsets or some other type of mischance.

The manufacturers of cars might study the situation that may happen when a collision occurs and make provision to prevent ignition of the fuel, or at least afford as much protection as possible against that eventuality.

In making this study of fires and of car wiring to

find its relation thereto, we discovered that the wiring is not armored in cars of a considerable number of makes. So far as these few cases examined go, it seems to be demonstrated that fires occur more often in cars on which the wiring is not armored than in those on which it is armored. Seemingly some invention might be produced which would shut off the ignition when a collision happens. Such may possibly come along in the course of time, but until it does the buyer of a car should be informed on obtainable results as to the statistics of cars which burn, so that he will have an opportunity to make his own investigation and buy with his eyes open to the dangers which loose and defective wiring may possibly produce.

Wiring that is not armored and which is not protected in any way, but simply hangs loose and depends upon insulation alone to prevent a possible spark or short circuit, ought perhaps to be looked into from the standpoint of insurance as well. Insurance underwriters might profitably evolve a code similar to that which now exists in connection with the wiring of houses, whereby the system would have to be passed upon before insurance can be considered; or, if this is not practical, at least to carry regulation to a point where insurance rates charged for the type of car that is under consideration will take into account the kind of wiring which exists. Such a procedure, if it could be embarked upon within a reasonable time, should shortly result in making all wiring protected in all cars.

The gathering of statistics on this subject of fires will be increasingly interesting this year and by the end of 1931 Connecticut will have enough so that the hasty conjectures which are now made can be corrected in the light of better knowledge. The Connecticut motor-vehicle statistical book for 1931 will have an additional section showing the causes of fires, with classification of cars burned, if that is at all possible.

A further question being looked into, but on which there is no basis to form even a conjecture at present, is whether there may not be some location where a gasoline tank can be attached to a car, that is safer than any other. Such a question must be studied carefully from the standpoint of performance before any statement, even a rash one, should be made; but it seems fair enough at this time to suggest that a tank ought to be as far from persons in the car as it can be placed. This does not take into account the necessity of fuel feeds, whether by pump, vacuum tank, air pressure or gravity; and, so far as any weight can be attached to it at present, it is simply my personal opinion. It is hoped that the future will develop a study as to the different placings of fuel tanks upon cars which may show something to induce the industry to consider this subject and work out the problem.

Growing Sentiment for Safety Glass

The department made a further study of cars with reference to the use of shatter-proof glass. This in-



ROBBINS B. STOECKEL

cludes a classification showing which cars have it, which are partly fitted with it, and which do not have it at all; also those makes which have it on some models and not on all. It seems to be fair enough to ask that every maker of every car advertise plainly, if he elects to mention it at all, regarding each and all of his models, whether shatter-proof glass is provided. It might be arranged, with increased safety results, that each maker will provide, at the buyer's expense, if such is a fair commercial proposal, that he may have safety glass throughout. The administrator who understands accidents and knows the invariable happenings which attend a collision where there is ordinary glass and who has had some opportunity to examine the effects of safety glass, will unquestionably attempt to teach his public to buy only cars which have such glass.

The tendency of the administrators, and the public tendency as well, I think, will be that if safety glass prevents cutting accidents stronger and stronger demand will be made for it in all cars. I do not think that the State has any particular duties about it but I do think a public sentiment is growing fast enough so that, even in present legislation, you may find a tendency on the part of legislators to insist that all cars be equipped that way. That has not demonstrated itself yet, but it is in the future; I have heard it talked about.

Must Educate Public to Free-Wheeling

Another phase of the work of a State needs to be discussed. Whenever a manufacturer puts out some innovation in connection with the operation of his motor-vehicle, it immediately becomes incumbent upon the State, through its administrator, to see that its citizens are duly informed about it. This is necessary in order that each may know what the attitude of the State toward the innovation will be, how the innovation affects enforcement of the laws and how enforcement and regulation will be applied to the vehicle.

Manufacturers are now bringing out the free-wheeling feature. This device will, to a decided extent, bring about a distinct departure from the driving performance to which States have been educating their operators. Up to now the education of an intending operator has been all along the line of keeping his car in gears and not coasting, as experience seemingly had demonstrated that coasting is one of the most dangerous driving actions that can occur on the highway. With this axiom in mind, coasting has been educated against more than it should be, for it can now readily be seen that, where such a device as the free-wheeling transmission is properly used, advantage will accrue and probably no additional danger be incurred; but the fact that all education so far has been against the practice of coasting means that a new activity along educational lines will be required and, as a probable result, it will be necessary for the administrator to explain as thoroughly as possible the State attitude about free-wheeling and gradually to settle into a condition where this improvement in automobile construction may be thoroughly understood.

It is reasonable to suggest, at least, even if it cannot be proved at present, that where there is any such great body of persons of heterogeneous accomplishment who have to learn a driving activity that is new, some will be incapable of mastering it with enough precision to make it a safe operation. On the basis

of averages, and probably in common with all other figures dealing with this matter, 85 per cent or thereabouts of the people who get free-wheeling devices will operate them well, and the operation of the other 15 per cent will be defective.

The 15 persons in 100 who will use it incorrectly would use any device incorrectly. They are persons who cannot do anything right and are the ones against whom we are directing this fight for safety. The idea that the State has about this is that those persons are the ones who must be watched, to whom education must be extended especially, and over whom discipline must be exerted.

Nevertheless, it stands to reason that education must progress through a thorough understanding of this device and of its attributes and qualities, so that everybody on the highway shall know that there is such a thing and that those who have it may be able to operate it safely and to make allowances for other operators of the same type of car with a full understanding of their problems.

General Principles Applicable to Free-Wheeling

Perhaps it is too early for any State to say how its policies are going to be directed in connection with this particular innovation. It has not yet been tried out thoroughly enough in mass driving under administrative observation so that any State can at this time know exactly what is necessary, but it might be proper to apply one or two general principles to its discussion. The first is that it seems reasonable to conclude that any person driving a car with free-wheeling will necessarily give more attention to hazards than when in the conventional gears. He has only one feature of control to depend upon where formerly he had two; that is, he depends upon his brakes entirely where before he had the engine plus the brakes. True enough, the brakes have been made more effective and undoubtedly will accomplish their function with satisfaction; nevertheless, the situation as it confronts the operator is bound to be that he will have to apprehend coming emergencies earlier. Another principle is that, because this is so new a factor in driving, each operator is bound to be more or less apprehensive and to some extent timid in its use. This probably is a great advantage, and, according to the principles which govern motor-vehicle accident frequently, if the situation in which the operator finds himself by reason of having a free-wheeling device on his car is somewhat uncertain, he probably will give more care, and only a little more care is necessary to provide a great improvement in the accident situation.

It has been taken by such State administrators as have considered it at all that free-wheeling is a step in the direction of eliminating the sliding-gear transmission and that the improvement to be looked forward to in the future in connection with motor-vehicles is somewhat along that line, so the time may not be far distant when a car will be evolved that is free from gears and which will accomplish everything that the car will do now, so that it will be easier to manage because there are fewer acts to perform. Also it would be entirely unfair and far from the spirit of co-operation to say at this date that anything that is an advance in construction is wrong because it has potential dangers which can be guarded against. All the dangers for free-wheeling are apparently along the line of inexperience, and it is probable that, with study

and knowledge, drivers will become skilled in the use of this device in a very short time and it will become a permanent contribution to motor-vehicle construction.

There is a question in connection with education which the States will have to decide very shortly. That is whether, in view of the fact that a car with a new attribute is about to appear on the highways, the State ought not to require examination in the operation of the new application; whether a State which is about to register a car that has a free-wheeling device ought not to require of its intended operators enough of an examination to prove knowledge of the capabilities of the device. The State must know that the operator will be able to use the innovation in its correct and intended way and that he has had enough experience with it and been taught enough about it so that it is safe for him to go upon the highways with it.

This particular free-wheeling principle supplies, within my memory, the first instance of manufacturers having, to some extent at least, informed the administrators as to their intention, but that information came almost too late for the administrator to do anything about it. Free-wheeling is here and free-wheeling education is not here; and it must be apparent that the two things should go hand in hand. This is one more reason for direct and continuous cooperation between State authorities and the manufacturer of motor-vehicles.

Headlighting Law Too Specific

The case of head-lamps is another in which we in Connecticut think now that we have tried to do too much. I think we would be better off, so far as lighting on the highways is concerned, if we should merely tell the lamp manufacturers in a general way how we wanted their lamps to perform and let them arrange to do it. We have told them specifically what results must be attained, and to attain those results we have drawn a decided restriction where it probably ought not to be drawn; that is, we have said that a lamp must reveal an object 200 ft. ahead of the car. The lamp manufacturer is confronted with the problem of selling a product to a man who wants a great deal more light than that, and probably it is right that he should have it. The demand is for more driving light. The psychology of the lighting law is peculiar. When you buy a car you do not go out in front to see whether the light glares; you try the lamps to see how far ahead they will throw the light for your use. You do not worry about the other road users and you never will; that is the concern which the motor-vehicle administrator and his police are supposed to induce.

It seems to me perfectly plain that, as I have stated several times, the problems in the different parts of this great Country are very different, in lighting and everything. In Michigan you can have speeds three times as great as we can safely have in Connecticut. So, in making lighting equipment, why not consider the proposition that the intensity of the light has a relation to the proper speed where the car is going to be used? In other words, if you are going to drive in Connecticut, illumination for 200 ft. might be enough. If you are going to drive in Michigan or in some other State where there are long, straight stretches of road on which you can go 50 m.p.h. at night without danger, you will need more light. I think that the policy which States have pursued of holding down to a standard the man who is going to operate the car is wrong to that extent. The

solution of the lighting question seems to me to be coming faster than ever before, as it is quite apparent now, which it has not been until very recently, that a man can be trusted to exercise courtesy and to do what he ought to do with his lighting device if he understands it.

I have been conducting an investigation in Connecticut, extending over a period of months with eight inspectors, as to the use of the two-filament lamp. Our highways are very rolling. You cannot go anywhere without meeting cars that are not on level highway. As a result, we have a considerable glare from devices that we have passed and which are all right under ideal circumstances. It constitutes a nuisance more than it does a danger, because, wherever there is a defect in the lighting to the extent that a man cannot see beyond an oncoming car, that operator will take more care and slow down. He does not go dashing through; it is not in his nature. For that reason I have considered that glare lighting due partly to the improper use of devices and partly to the rolling nature of the country, or however it is produced, is a safeguard against night-time accidents. In our statistics comparatively few accidents can be traced to glaring lights, but the glare is a decided nuisance.

One or two inconsistencies that exist in Connecticut will be straightened out. We have a law restricting the candlepower to 21. A bill is already in the legislature to make the 32-cp. lamp legal. That will have to be brought into line and we are going to correct it right away.

Driver Courtesy with Two-Filament Lamp

In the use of the two-filament lamp a principle is involved which is not included in any laws. This is that, to have an offense, there must be someone to offend, and the theory of the two-filament lamp seems to be that it may be used to its furthest lighting capacity only when nobody is approaching but must be turned down to the standard when somebody is approaching. Education is now accomplishing that; one meets more compliance with this courtesy on all highways, but a decidedly large number of all operators still do not comply with lighting requirements in this respect; the drivers keep their lights up all the time. This is largely a matter of neglect.

A consideration of the idea of protection for the car owner ought to take its place in this problem. An owner is a legal outlaw unless his car and its equipment are legal, and, should anything happen to him so that the opposing interest in an accident case might choose to take advantage of the situation, he might find himself out of court with a judgment against him.

By far the most important defect in the whole lighting situation arises through the tendency, on the part of those motor-vehicle manufacturers who buy their head-lamps, to bargain round to get the cheapest lamps that will be within the law and which are of sufficiently good appearance and performance to satisfy them for the purpose of installation on their particular makes of car. In this sort of buying, the buyer is offered various types for installation and inducements in price are made to him. It seems to a prejudiced observer that the accomplishment of strength in construction and the subject of maintenance have not been given sufficient attention, and that the competition to build lamps which will fulfill State requirements within the limits of low cost to sell to manufacturers has been at the expense of

these qualities. The reason that so many lamps that are out of focus are in use on our highways today may be that the term of maintenance of the lamp is nowhere near up to that of the rest of the car. We feel that the duty of the manufacturer is to provide his car with lamps which are adequate for and comparable with the car, not only in their construction but also in their maintenance.

Old Cars Usually Well Maintained

Not very long ago the president of the American Automobile Association made the statement that there are upon the highways of the United States some 8,000,000 cars which are too old to be safe. Any administrator who has had close contact with car maintenance and who, through his inspectors and policemen has for years had to examine cars as to their continued safety on highways, will testify that most of these old cars are safe and that such a statement ought to be somewhat qualified. The old car is not necessarily unsafe. Even very old cars well taken care of are among the safest vehicles on our highways, and it would not be the slightest exaggeration to maintain that inspectors in any State find in the course of their duties many thousands of old cars which are in better condition and have better equipment and in every way are more adequate for road work than newer cars.

It would seem from the experience of an official that the time when a car is most out of line as regards safety is after it has been on the highways for a comparatively short time. A new car comes upon the highway and, after being operated for a period of time, gradually gets into such a condition that its adjustments need to be attended to although it still looks like a new car. If that is not done, the reason usually is that the owner still thinks of it as a new car not needing any attention, whereas it apparently is a fact that a car needs to be attended to within a reasonable time after it first goes onto the highway and thereby kept in adjustment, broken in carefully and watched as to its performance and safety qualifications all the time. If an owner has taken care of a car as he should have done and given attention to all these things, there is no reason why the old car should be any less safe than the new one.

In general, however, the old cars on the highways, by reason of having been used longer, are more likely to be out of condition than newer ones. Consequently, inspectors on the highways who have the duty of examining for maintenance will pick out of the traffic lines those cars which look as if they had traveled a good many miles rather than the new-looking cars, and after a while even officials get the idea that the old car is a menace. It probably is true that a greater proportion of officials associate the idea of maintenance with the older cars rather than with those less than two years old, but the question of safety depends entirely upon the decision of the owner as to how to take care of it and whether he uses reason or not.

Car Maintenance of Greatest Importance

The maintenance of condition on the highways is of the greatest importance and is the one particular place where State officials ought to use an increasing amount of enforcement and direction. That is being recognized, and in almost every jurisdiction periodic tests of brakes and lights and a checking up of all equipment are now made. That comes first in most instances in connection with public-service motor-vehicles of various types. It

is natural that it should do so because public-service motor-vehicles carry passengers for hire and each of them is entitled to know that the vehicle in which he is riding has had the kind of supervision which a State can give. Officials will continue increasingly to supervise maintenance.

We have a very good system of inspection in Connecticut which sometime may become a model. We have a teletype connection in the Motor-Vehicle Department with which we can correspond instantaneously with all of the State police and all of the city departments not only in Connecticut but well up into Massachusetts. With that arrangement, my inspectors can make an appointment with the police force in any one of the cities or villages to make inspections for any purpose with the aid of the local police. The local police are glad to do it; they come out and give us all the cooperation and assistance we need. In making those inspections, the State's attitude is absolutely and finally a corrective one. We are not in any way intending to discipline, but, if the policeman who is along finds an extreme case of some driver who is clearly and plainly negligent, he does the arresting and the prosecuting. That is why he likes to help us.

That activity, I think, has brought equipment in Connecticut to a reasonably good operating condition. We are keeping right at it, recognizing that at this time, with business conditions as they are now, probably our cars will continue to run down faster than they have in the past and there will not be quite so much replacement. I hope that will not be so, but we are looking at it in the expectation that it may be.

Manufacturers Should Aid in Junking Cars

Maintenance extends not only to the car itself but to all of the functions performed by the accessories, that is, to those other units of machinery attached to the car which help it to perform its duties, such as the lamps, the brakes, the windshield wiper and whatever other portion of a car is essential to its correct operation. Maintenance must be studied more carefully than it has been studied. The car manufacturer can help through his dealers; there should be a more distinct and careful supervision by manufacturers of used-car sales. Every manufacturer might exercise his influence with his dealers to see that cars are junked when they ought to be and not again put on the road, or that the dealer is obliged, before he puts a used car on the highway, to have it in such condition that he can guarantee its safety as a mechanism. In some States this is now required, and the tendency is toward requiring a dealer's report on each sale of a used car, a part of the report to be a statement of condition over the dealer's signature. That will help conditions on the highway and may require a better conditioning of used cars than is now given.

To get old worn-out cars off the road is primarily a manufacturers' problem. States enter into it to the extent that they are the source of enforcement by which unfit cars are either ruled off or correction is required. In some instances the manufacturer is already making an inducement to dealers to get rid of cars. To do that properly, used-car destruction plants are needed, and it is possible that within a reasonable time manufacturers will see that the junk car presents a problem for States to deal with in which they must eventually assist by salvage of parts and in whatever other way the problem can be met as a sound business procedure.

Junkyard Law Eliminating Unsafe Vehicles

We are trying hard in Connecticut to get wornout cars off the road. We have evolved a junkyard law. It contains a joker that is working out very well. We did not know it was a joker when we put it in. A junkyard is any place where two or more old abandoned cars are gathered together. When we started there were 191 such places in Connecticut. We had the measure introduced in the last session of the legislature and it proved to be very popular and went through both houses unanimously without any effort to stop it. But I found that I was saddled with a law that was unconstitutional and it has to be amended in this session. Under that law I had to proceed with diplomatic caution, using my inspectors as diplomats and not as officers, as the theory is that we are the friends of the public, and we do not make any arrests.

The inspectors went out and talked these "junkyard" men into abandoning the picking up of these old wrecks. Out of 191 of those yards we corrected 185 in that way. The rest of them all have written agreements with me whereby they pick up a certain number of cars per week and junk them.

It is going to be a long time under existing law and practice before we get rid of the very worst of those yards, but they are going to be gradually eliminated and we are making an effort to expedite it. Our law will need to be changed to make it constitutional. It will be a zoning law and will be administered by towns with our help. The joker in that junkyard law is that no junkyard man can sell a used car without reporting its condition to the Commissioner of Motor Vehicles and certifying that it can safely go upon the highway. These junkyard men are all dealers licensed by the State, and they certainly give us those reports and have lived up to the conditions in them, all of which has helped our equipment situation.

Growing Sentiment against Noise

There is some safety equipment on each car which deserves comment. The windshield wiper, which in some States is now obligatory, has prevented thousands of accidents. It is possible now to combine it with a sleeter, and these are safety mechanisms of the highest order.

One item of equipment about which there is a growing sentiment, in my opinion, in the East, is the horn. The newspapers and all of our publicity agencies are giving considerable attention to a campaign against noise. The legislature is being besought now by a number of people who are the advance troop of an army of this public sentiment, which I am sure is coming in the cities particularly, to do something about automobile horns. What they are going to propose shall be done I have not the slightest idea. I have no remedy to suggest, unless it is to try to make the horn musical. There, again, the difference in location and in the character of the problem enters. Probably out in the Central and Western States where you want to give a signal that is to be heard a long distance ahead, a powerful horn is desirable, but with us, where everything is crowded together and one hardly misses a man by more than an inch at any time, we do not need any such horn. I think that we are going to have introduced into the

legislatures in the East some anti-noise measures, and, so far as the motor-vehicle is concerned, they are going to attack the horn.

Perhaps this paper has covered enough subjects in detail so that the general policies which States are bound to pursue in connection with manufacture have been plainly indicated. There is no question at all, as one looks back upon the past, that the motor-vehicle has, through lack of sufficient foresight, created in transportation many situations which today exist to the economic detriment of persons who want to move about in cars and to the injury and damage, and sometimes death, of those who are affected by their operation.

Such a situation as now exists on account of the parking of cars is entirely due to the lack of vision in the early days of what difficulties and dangers such a condition would produce. Now we have a problem needing to be cured, which 20 years ago might have been prevented.

Another problem had to do with highways, but that was so pressing and its solution has become so exceedingly necessary to provide highway safety-engineering in connection with car operation that the subject has more or less taken care of itself, so perhaps it is possible to call attention to the necessity for looking ahead in car construction, not for one year or two but for five or ten years, and trying to provide for the contingencies which may be part of motor-vehicle transportation by that time.

Some great factors that have to do with car operation must be settled almost forthwith on a basis of future performance. The greatest of these is highway surface. Can we continue to build roads increasingly wide and increasingly straight and in volume enough so that all of our future transportation needs can be met with a sufficient supply of roadage? Can we foresee what speed will bring about? Shall we say now that speed has reached its maximum on the existing traffic layouts and on existing highways, or shall we consider that the manufacturer is justified in looking forward to an era when speeds will be greater? In speaking of speeds, average speeds only are meant.

Finally, the safety factors to which this paper has been devoted ought to be continuously in the foreground of every manufacturer's program. Each State will try to teach its citizens how to buy cars that have the best safety records, appliances and accessories. This does not necessarily mean that every car will be safe throughout, but it will mean that inside of the next few years, as a result of the educational campaign by States that is now beginning, every man who buys a car that is unsafe in any quality whatever will do so with a full knowledge of its unsafe features.

THE DISCUSSION

CHAIRMAN MILLER MCCLINTOCK²:—It must be very heartening to you who are responsible for the design and construction of motor-vehicles, that at least one State in the Union has adopted such a rational and constructive policy with respect to legislation and enforcement as it affects motor-vehicle construction and maintenance.

D. BEECROFT³:—The Society is to be congratulated on having Commissioner Stoeckel come here. I have followed his work for upward of six years and have

² M.S.A.E.—Director, Albert Russel Erskine Bureau for Street Traffic Research, Cambridge, Mass.

³ M.S.A.E.—Manager, New York City, Bendix Aviation Corp., New York City.

noted with a great deal of pleasure the studious and analytical character of the work the Connecticut Motor-Vehicle Commission has been doing. The Commissioner's announcement of the policy of relying upon the manufacturer to provide equipment that will meet the rational safety desires of the community is a notable step forward and it is one that is going to create great enthusiasm throughout the industry.

It is excellent, too, perhaps, that the Commissioner has had the opportunity of coming into a city where these vehicles are manufactured, and it is certain that during his stay here he has had an opportunity of seeing this problem a wee bit more from the manufacturers' point of view. That appeals to me particularly in connection with the suggestion regarding the lights. Speaking as an operator, we sometimes in a single day drive through three different States. Not infrequently we drive after dark through Massachusetts, Connecticut, and into New York State. A year or two ago, when we drove from New York State through New Jersey to Pennsylvania in the same day, we were embarrassed as regards the head-lamps. The lighting must be handled from a National point of view, because in the course of a night's drive the motor-vehicle frequently traverses more than one State.



DAVID BEECROFT

Industry Should Study Accident Analysis

I have been very much impressed with the analysis of accidents that Commissioner Stoeckel's department has carried out. Each year for five years it has printed a very comprehensive report of the accidents in Connecticut, the number of accidents that have occurred at night, the number that have happened in the day time, the number each hour of the day, the number in the urban areas and in the suburban and rural areas, and the number at road intersections. We have not made enough use of those figures. One that always remains in my mind is that 44 per cent of the accidents occurred at highway intersections, and I have often wished that the analysis could be carried a little further, to show the reason for those accidents at intersections. Are they due to the highway structure and the environment at such points, so that an open view of the highway is obscured? Are they due to failure of the brakes or to the presence of a blind spot in the vehicle? Is the eyesight of the operator defective? If we could learn the causes I believe we could attack the problem successfully.

Dr. McClintock has for several years been chairman of the Advisory Committee of the National Safety Council. I know of the work that he has tried to do in keeping the increase of fatal accidents down, and I know that his successor this year is doing his best to find some more feasible way in which we can learn more regarding these accidents so as to profit by them to a greater extent.

* M.S.A.E.—Patent section, General Motors Corp., Detroit.

I had hoped that the Commissioner would say something regarding the periodic inspections that are being talked of so much and concerning which there are so many diverse and contradictory views among the different States.

CHAIRMAN MCCLINTOCK:—I certainly confirm what Mr. Beecroft has said regarding the excellence of the digest of accident statistics which the Motor Vehicle Department in Connecticut issues annually. Commissioner Stoeckel has generously suggested that any of the members who desire may give him their names and addresses and he will see that the last annual digest is sent to them.

I believe that, as policies of making careful analyses and drawing conclusions from them are developed by the motor-vehicle departments in the other States throughout the Union, the information will afford the industry a valuable indication as to the most comprehensive and conclusive laboratory experiments to which motor-vehicles can be subjected. The real test of the vehicle from the standpoint of safety is, after all, what happens when millions of them are in the hands of actual users, in the infinite variety of circumstances which confront the drivers.

Obstacles to Consulting on New Devices

J. H. HUNT*:—It is a wonderful step forward to have a man in the position that Commissioner Stoeckel occupies come and tell us that the responsibility is up to us, that his department is going to collect information as to what goes wrong with the different types of equipment and put it up to us to fix the equipment. Speaking as an individual from the viewpoint of the automobile engineer, not from that of any particular manufacturer, it seems to me that some manufacturers are using various details that do not commend themselves, but I am sure that every one of those manufacturers sincerely believes that they are thoroughly satisfactory devices for use. I might in the same way sometime endorse some device and put it into service with a mistaken belief as to what might work out. If the

commissioners of the various States can organize their work so that we can promptly obtain information as to how new devices actually work out, we can soon correct any mistakes we have made.

With regard to insurance, which was referred to in the paper, the insurance rates, I understand, are now determined entirely on the basis of experience. Cars are being judged, not on the current models, but on the cumulative effect of past models, and the rates our



MILLER MCCLINTOCK

customers pay are determined by the experience which has been met with in those cars. The question of fire insurance rates became quite acute several years ago, and some automobile organizations got very busy and cleaned up such fire hazards as existed. Apparently, they were so successful that, as the Commissioner has pointed out, we have very few fires today in which defective equipment is the proximate cause; but a collision

or some other accident creates the possibility of a fire that could not be anticipated by the methods that were worked out some time ago by the underwriters. That suggests another viewpoint from which we might work.

A great deal is to be said for Commissioner Stoeckel's suggestion that projected designs incorporating new features be talked over with the regulating authorities. On certain types of equipment that is entirely possible, and we should go farther, I am sure, than we have done in the past. There is no reason why anything that would involve any questionable practices regarding the legal situation should be held back until too late for change. However, the competitive situation and the relation between a manufacturer and a dealer with a stock of cars is such that it is dangerous to start talking about new designs very far in advance. Moreover, the manufacturer may not have enough cars available to show to all of the commissioners of all of the States far in advance of the time they are to be released for production. A great deal of difficulty is involved in complying with such a request. From the viewpoint of the automobile engineer, it might be very satisfactory if all commissioners would attempt to pre-inspect and pass upon all new car models. That would surely provide a lot of jobs for some of us who are sitting on the edge of the seat on account of the numerous mergers and the reduction in the number of companies doing business. The commissioners would need some of us who are getting to the point of superannuation.

It is exceedingly difficult to foretell how a new construction will work out in public use on the road. Therefore I am delighted that the Commissioner has expressed the belief that the manufacturer can solve the problems, and I think that the program he has proposed is possibly the best that anyone could propose; namely, to tell us what actually goes wrong.

Utility of Dual-Beam Lamp Restricted

R. E. CARLSON^a:—I am particularly interested in the lighting question. Our lighting at present is a compromise between the ability to see and the production of glare. The solution which we now have, namely, the provision of dual-beam lamps on our cars, if properly used, provides adequate lighting for safety and comfort at high speed and gives the operator a means for minimizing the glare which might otherwise exist when meeting other cars. I believe that at present full advantage is not being taken of the system.

Under some of our current State regulations the upper beam, which is intended for high-speed country driving, is aimed so that it is well below horizontal when the car is empty, which is a condition under which the car is driven a large percentage of the time. This aiming allowance is provided so that, when the car is

loaded, the upper beam will not be raised too high and be unduly glaring, and it was necessary with the older single-beam system where no provision for relief was made. From a safety viewpoint, I believe that now we could profitably raise the aiming, provided the drivers were educated so that they would lower the beam when meeting other vehicles. Does Commissioner Stoeckel feel that a sufficient number of car drivers understand and use the lower beam to justify higher aiming of the upper beam? Also, does he favor compulsory inspection, at least once a year, of headlights as a prerequisite to registration of the car?

ROBBINS B. STOECKEL:—I have a thorough belief in the future courtesy of the operator, not only in connection with using his head-lamp beams, but in connection with everything about driving his car. There is an increasing amount of compliance with the courtesies of the road in the use of the upper and lower beams. I think it is recognized that the upper beam supplies needed light for occasions when, in country like that in Connecticut and Massachusetts, the lower beam is inadequate. At the same time, I can see that the upper beam might be used too much and that we might get faster speed on the highway than is safe in our States if there were light enough.

To Inspect Cars Before Registration

The question about compulsory inspection is, in my mind, a problem for the State. Next year we probably shall lay out an inspection course in Connecticut under which the inspectors of the department will circulate among the cars as they come up for registration and will order the drivers of the ones that they think should be inspected about any point to take a test on that particular item.

With reference to tests, I should like to suggest that it is a bad practice, in my opinion, for automobile clubs to conduct tests on a basis of perfection. For a club to determine as a result of a test that 61 per cent of all the cars are defective makes it look as though a State's cars were in very bad condition. I think the test ought not to be for perfection but for safe road service.

Our own test for that purpose does not agree within thousands of cars with the findings of the automobile clubs. The tendency ought to be to establish some basis for a test for safe use on the highways.

Higher Average Speed an Advantage

A. K. BRUMBAUGH^b:—There is a tendency in the truck and motorcoach industry to install larger engines. The defense of the idea, as it stands, is that such vehicles will be able



R. E. CARLSON

to maintain higher average speeds over the road and thus keep up a better schedule speed without reckless running. That may be possible, but our experience shows that, when a more powerful engine is put in, it means larger loads and more tractive effort.

Does the Commissioner feel that the public interest will be served by permitting these vehicles with



J. H. HUNT

^a M.S.A.E.—Commercial engineer, Westinghouse Lamp Co., Bloomfield, N. J.

^b M.S.A.E.—Commercial engineer, White Motor Co., Cleveland.

larger engines to operate on the highways of the State?

MR. STOECKEL:—With us the speed problem is becoming a problem of average speed, and we are trying to step up the slow vehicles. We are successful in that to a very decided extent. Connecticut lends itself very decidedly to one-way traffic. I am expecting that the time is soon coming when we can have one-way traffic between our large cities in Connecticut. When that time comes we shall expect the motorcoach and the truck to keep up with the procession, and will try to make them do so. It is all to our advantage to have additional speed, possibly by a larger engine or in any other way in which it can be obtained. In fact, the slow driver is much more of a problem with us now than is the fast driver. I have spent half of my time, so far as enforcement goes, in the last two or three months trying to get some policeman steamed up so that he would arrest one of these low-speed drivers who was holding the line back and prosecute him for reckless driving. Perhaps you do not think that is reckless driving, but it is. It is inconsiderate of everybody else on the road. It tempts the drivers following behind to do impossible acts. It is one of the things which makes trouble, and I am going to succeed before I get through. I have taken many licenses away from slow drivers and made them beg before they got them back, on the basis that they are inconsiderate of the rest of the users of the highway.

Vehicle-Weight and Size Restrictions

There is this feature about the truck: We have a maximum gross-weight limitation of 28,000 lb. As long as this provision remains in the law you can put as heavy engines as you want to in the trucks, but the load will have to come down correspondingly if that factor is involved. Another feature of our law is this: It is overloading to load a commercial motor-vehicle beyond the capacity that the maker rates that vehicle for registration. Our theory is that, if a maker guarantees his truck for a definite load, we ought not to permit any heavier load to be carried, because we assume that the safety mechanisms of that vehicle are intended to control that load and no more. We have held the drivers and fleet operators rather closely to that, especially in the spring. Usually it is fairly safe in the dead of winter to carry a little extra weight, but in the spring the policeman seems to think it is time to do some-

thing about it and we always have a large number of overloading cases and complaints under both those sections, the section limiting the gross load and the section which prohibits too much load for the safety mechanism. We have a good many convictions for that each year.

One of our greatest problems with large vehicles is that our law restricts the unit length to 40 ft. We have held everyone to that. Also, we have a minimum speed for commercial motor-vehicles; true, it is 12 m.p.h., but it was necessary because somebody figured out he could build a truck body on a tractor and run on our roads at about 8 m.p.h. You can see what that would do in our congested country.

We are not having any trouble now with large vehicles in traffic. They maintain the average speed very well except that some of the great motorcoaches go thundering through our State, the people who own them taking advantage of the fact that they are interstate vehicles and consequently we have no jurisdiction over them except under police regulations. We can arrest one of those drivers for driving too fast, but it is poor practice to arrest and fine him for speeding and have him do it again. That is one of our problems with which we are struggling now.

We were in hopes that a law would be passed by the Congress giving the States and the Interstate Commerce Commission control over the interstate operators. They are the outstanding offenders at present with the big vehicles. We have a corresponding number of private vehicle owners who go too fast, but they are not unusually fast in Connecticut; in fact, the conditions are such that it has become so unsafe to be a solo performer that it is not being done. I think that is the main reason for a big decrease in accidents. We came through 1930 with 50 less people killed than in 1929. We had 15 per cent fewer accidents, and the whole situation was decidedly more encouraging. My theory is that the general traffic conditions have become so dangerous that they call for extra care. The man who would ordinarily take a chance is compelled by the very nature of the hazard to go slow. You do not have accidents in places that are obviously dangerous. The accidents happen where conditions look fairly safe but where a situation for which he is not prepared suddenly confronts an operator. That is the principle which I think controls accident frequency in Connecticut.



Transportation Trends Cited

Two papers were presented at the Transportation Session of the Annual Meeting held Jan. 21. Future Needs of Motorcoach Operators was the subject chosen by John B. Walker, and Design Factors for Future Motorcoaches were analyzed by D. W. Russell. Both papers are published in full herewith, preceded in each case by an abstract of the paper. The discussion which follows applies to both papers, and is preceded by a synopsis of the major points contained therein.

Future Needs of Motorcoach Operators

By John B. Walker¹

THE EFFORTS of American designers to date in improving all classes of motor-transport equipment have borne good fruit, according to the author. The first motorcoach was developed in 1906 by the Fifth Avenue Coach Co., New York City. Not until about 1915 did so-called motorcoaches begin to appear in any great number on the highways. He also refers to the makeshift contraptions which were then in use, comparing them with the de luxe coaches of today.

After referring to the difficulties encountered during the development of the motorcoach, the author considers what effect the requirements of the operator will have on future motorcoach construction and performance. He analyzes the questions that arise in

this regard, mentioning recent changes and changes projected in both the United States and Europe. His conclusion is that motorcoach design is showing substantial improvements in all its various phases.

Manufacturers and operators are provided now with a much better understanding of each other's requirements. There is less disposition on the part of the manufacturers to produce equipment on a "take-it-or-leave-it" basis. The operators are thinking of equipment purchases less and less in terms of price and more in terms of quality construction, longer life and lower maintenance expense. This open-minded attitude makes certain that future motorcoach developments will tend toward perfection.

AUTOMOTIVE engineers who design and build the equipment used by the bus operators of America are interested in every phase of the operation of this equipment. They want to know what the representatives of each class of operation—city, suburban, and long-haul—think of the present equipment and what should be done toward developing future equipment better suited to the needs of its particular class of transportation service. Their efforts to date in improving all classes of motor-transport equipment have borne good fruit. When we pause to consider the development that the last seven years have witnessed, engineers, designers and manufacturers can take just pride in their accomplishments.

In 1906, the Fifth Avenue Coach Co. developed the first motorcoach, which was put into service in 1907. Not until about 1915 did so-called buses begin to appear in numbers on our highways. These, too, were largely modified trucks or elongated passenger-cars. Faulty design, inadequate powerplants, poor brakes, truck-type springs and poorly built over-weight bodies characterized these early models. It is a far cry from such makeshift contraptions to the de luxe coaches of today, yet it is a development of but a few years.

When we consider also that the position of bus transportation as an industry has but lately attained

anything resembling stability, that it has had to contend with the opposition of other forms of transportation, that it has met difficulty in securing adequate financial backing, and that its potentialities from the manufacturers' standpoint were not to be compared in promise or profit with those of the automobile or truck, I feel that the operators owe a debt of gratitude to the manufacturers, to their designers and engineers who had the vision and foresight to play along with this "infant" industry.

I have been told that the cost of designing, testing, tooling and development incident to the production of a new engine of the size used in today's larger motorbus equipment may run to a quarter of a million dollars. Somebody has to sell a lot of motorbuses to get that money back. Somebody has to do a superb job of selling to induce a board of directors to approve such expenditures. The fact that it has been and is being done is, as I said, worthy of tribute from the bus operators of America.

Although I am to discuss what effect the requirements of the bus operator will have on future bus construction and performance, I am not, in the strict sense, an operator. However, in my four years of contact with the bus business I have had the opportunity to observe practically all phases of its development. From these observations, from investigation of the problems, from ideas of my own and from those

¹ Sales manager, Greyhound Management Co., Cleveland.

of other companies' operating and maintenance executives, I will make as good an analysis as I can of the subject.

To analyze this subject intelligently, it must be broken down into several questions, and an answer must be given to each. For instance, before we can determine future requirements we must ask such questions as:

- (1) What are the present-day requirements of the bus operator?
- (2) How well does present-day equipment meet these requirements?
- (3) What influences are at work to modify present requirements? In other words, what major improvements are indicated?
- (4) What can the bus operators and the manufacturers' designers and engineers do to hasten their inauguration?

Answering question (1), in the final analysis the requirement of the bus operator is for a coach that will do the job at hand to the satisfaction of the rider and will continue to do so with proper economy in operation and maintenance costs for a long enough time so that its fixed depreciation will bear a proper relationship to gross revenue. This is a rather large order and cannot be filled without close and intelligent cooperation between the bus operator and the manufacturer. Such cooperation cannot exist if price competition is to continue as the basis for the sale of equipment. Predictions are always dangerous, but I sincerely believe that the time is not far distant when bus manufacturers will build to specifications established jointly by their engineers and designers in collaboration with the operating and maintenance executives of the operator. Price will not be, and equipment designed to fit the task at hand will be, the major factor. Such equipment might conceivably be built on a "cost-plus" basis.

No other unit of transportation equipment lasts so

short a time as the motorbus. If we are to develop profitable operations, a more specialized type of vehicle—one designed for the particular job at hand—must be developed. Into it must be put the quality of material and workmanship that will assure not only satisfactory operation and reduced maintenance but longer life.

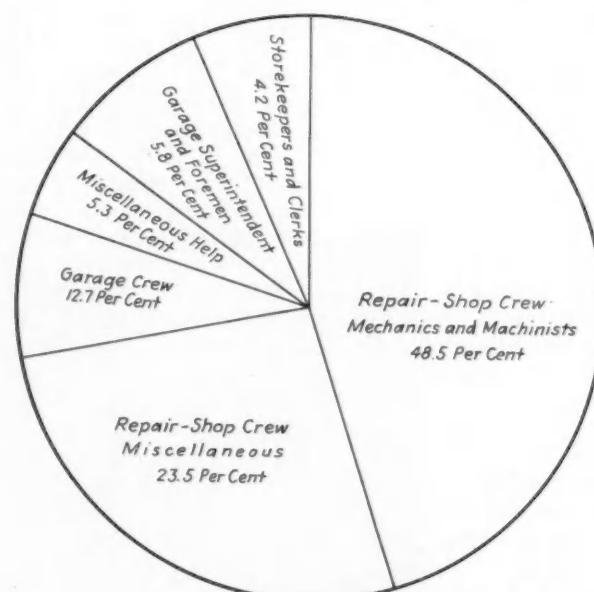
Ideal Solution Outlined

The ideal solution of the problem is the development of equipment that possesses greater riding-comfort, more appeal to the traveling public, and that at the same time will be easier and cheaper to maintain. With present maintenance costs running between 4 and 8 cents per mile, depending on size of equipment, season and mileage, and averaging with the larger companies more than 5 cents per mile, in view of the enormous mileage now operated it is evident that any improvements tending to reduce maintenance costs will be reflected in tremendous savings to the operator. The operators are doing their part in this. Exhaustive study has been made of every maintenance operation, specially designed plants have been built, periodic inspection and unit repair and replacement systems have been installed by most of the larger companies, and real progress has been made in scientific maintenance procedure.

For example, the maintenance costs on those operations under the jurisdiction of the Greyhound Management Co. have been reduced approximately $1\frac{1}{2}$ cents per mile in the last three years. Had they not been reduced by this amount, our maintenance costs for 1930 would have been \$1,525,000 more than they were. It is up to the manufacturers and their designers and engineers to further this program of reduction in maintenance expense through developing equipment the units of which require less frequent attention and, when service is required, are more accessible. Mechanics have told me that they have virtually to stand on their heads to work on certain units



Fig. 1—Division of the Maintenance Dollar According to Body, Chassis, Engine, Material, Labor and Overhead



DIVISION OF THE GREYHOUND

Fig. 2—Distribution of the Maintenance Payroll Showing the Percentage of Expense According to Occupation on Each Class of Work

in present buses. Manufacturers should assemble bus units with the thought in mind that maintenance is a continuous process and that accessibility is of vital importance in reducing maintenance labor-costs.

Charts are presented which indicate, in Fig. 1, the division of the Greyhound Management Co.'s maintenance dollar according to body, chassis, engine, material, labor and overhead; in Fig. 2, the maintenance payroll, showing the percentage of expense by occupation on each class of work; in Fig. 3, the percentage of maintenance cost to operating cost; and, in Fig. 4, the percentage of maintenance cost to total cost. The facts brought out in these charts are not applicable to all bus companies, but they will serve as a fair index of the relative expense of various maintenance procedures. Further, they establish the importance of the reduction of maintenance expense.

Powerplant a Major Problem

One major problem, if not the major problem of the operator from both the operating and the maintenance viewpoints, is the powerplant. Because of the fact that the motorbus uses the streets and highways side-by-side with the automobile, the demand has been for a vehicle having speed, acceleration and deceleration that compare favorably with the average automobile. This has necessitated, especially in the larger-capacity coaches, a larger engine, capable of delivering greater power-output for sustained higher vehicle-speeds.

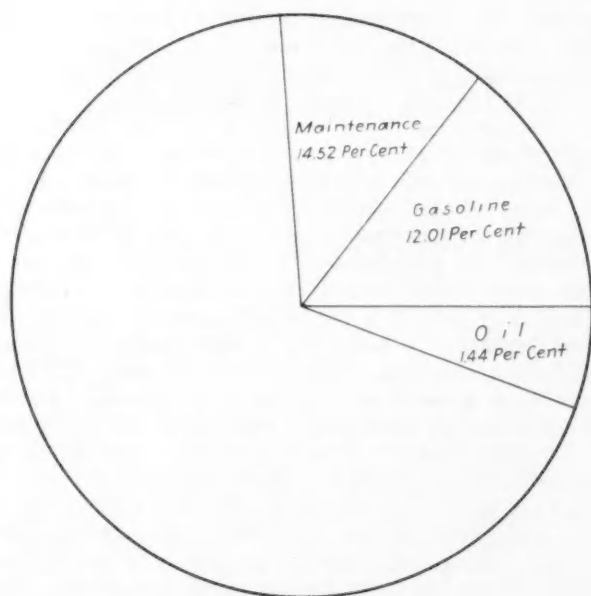
The general tendency in the newer engine-design seems toward greater power-output, and many of the new models are designed to deliver a higher torque at lower speed. Practically all manufacturers have increased their horsepower-weight ratio in the last few years. The extent to which this can be still further increased is a question which automotive engineers are better qualified to answer. However, we must all remember that as the horsepower-weight ratio increases, the weight of the chassis and the cost of operation must increase with it and there are the legal limitations on

weight, length, width and the like, which of course must be considered.

In the later designs, maximum engine-speeds are held within more reasonable operating limits, thus permitting the delivery of full power-output over long periods without harmful effect to cylinder-walls and operating parts. In many cases the power output has been increased materially without enlarging the bore. This is accomplished by better carburetion and manifolding to secure reduction in back pressure, quicker and more complete scavenging of the combustion-chamber and a more uniform velocity of exhaust gases. Better control of hot-spot temperatures has also aided in improving power-output and, similarly, much has been gained through more uniform control of water-jacket temperatures.

The use of oil filters is now almost universal and there is also evidence of an attempt on the part of the designers to develop some means of cooling the engine lubricant. Oil cooling promises certain definite advantages that should react to the benefit of the operator. It would assure easier starting, since lighter oils could be used; would mean reduced oil-consumption due to more constant viscosity; and would provide better lubrication, longer bearing-life, less carbon-deposit and, consequently, lower repair-costs.

Overhead valves apparently are becoming more popular, especially in heavy-duty powerplants. No less than four manufacturers are using this design at present in bus engines. There have been a number of interesting trends in the use of new materials which are designed to withstand the severe requirements of the modern bus powerplant better. Exhaust valves in the majority of cases are silchrome, thus eliminating much of the former trouble due to burning, warping and pitting. Salt-cooled valves are used by a number of manufacturers, with the object of promoting more rapid dissipation of heat from the valve heads. Nickel-iron material is being largely used in cylinder-blocks. A number of manufacturers are employing steel-backed



MANAGEMENT Co.'s COSTS

Fig. 3—Gasoline, Oil and Maintenance Costs in Percentages of the Total Operating Costs

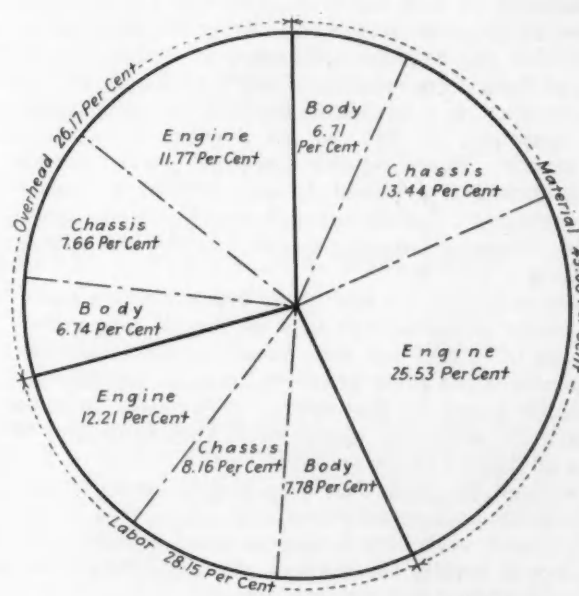


Fig. 4—Percentage of Maintenance Cost to Total Cost

bearings, and one maker uses a "chocolate" bearing made of 70 per cent of copper and 30 per cent of lead.

A growing interest seems to be evidenced by both manufacturers and operators in the development of crude-oil fuels. Some manufacturers and at least one operator are experimenting with Diesel powerplants. A European development is a fluid flywheel with self-changing gear-equipment for buses, which has been developed by the Daimler organization in London. It is a device which employs a fluid as a transmitter of energy. No clutch or friction contact is involved in the transmission, and added to the fluid flywheel is a four-speed gearbox with all four speeds silent.

This latter move seems to be in the right direction, at least as applied to the elimination of noise. Transmission design has changed but little since the early days of the automobile and there is no such thing as a quiet transmission, especially a bus transmission. Those who have traveled over the mountains by bus and endured for hours the rasping grind of the transmission know whereof I speak. Further, something needs to be done to provide greater flexibility in the transmission.

Carburetion and Manifolds

Important experiments have recently been conducted on a new carburetor known as the "Juhasz Device" before a group of engineers and health officials in New York City. This device is said to give almost complete combustion with little or no carbon-monoxide production. It is comparatively free from noxious odors and gives mileage increases which, in some cases, amount to 40 per cent. Another advantage of the device is that it will utilize either gasoline, kerosene or fuel oil.

Carburetion and manifolding are of considerable importance to the operator, as will be shown in accompanying statements. In an attempt to increase mileage on gasoline, the Greyhound Lines conducted a test by installing a new-type manifold on one of its coaches. This test was conducted for a total of 8815 miles, during which 2227 gal. of gasoline was consumed. Before installation of the manifold, the average mileage per gallon of gasoline was 3.66. After installation of the manifold, the average mileage per gallon was 3.958. This showed a fuel saving of 0.298 miles per gal. which is equivalent to a saving of \$0.0025 per mile, using 12-cent gasoline, or \$15 on an average of 6000 miles per month. Based on the combined yearly mileage of the affiliated Greyhound Lines—120,000,000 miles—if this saving of 2.5 mills per mile could be made general it would mean a saving to our companies alone of \$300,000.

I am sure that we and other bus operators could use this money as advantageously as the oil companies. A fraction of a mill per mile means considerable to bus companies when their yearly mileage is considered. It is readily apparent that even a very slight increase in carburetion efficiency would mean thousands and thousands of dollars to an operator in the course of a year. There must be room for considerable improvement in carburetion and manifolding and, since this is one of the quickest and surest steps toward economy to the operator, it merits the serious consideration of the designer, engineer and manufacturer.

Other Important Factors

It should be noted that on the average 10 to 25 per cent of the total buses owned by motor-vehicle carriers

are held as reserve or "stand-by" equipment for replacements. Surely such procedure is costly and indicative of unsound business when as much as one-fourth of the rolling equipment has to be held in reserve in anticipation of failure of the balance of the equipment.

For a period of seven months—May to November, inclusive, 1930—the Greyhound Lines were required to completely tear out 189 engines in their various garages east of the Mississippi. The time required was 3 to 5 hr. for taking out and the same time for replacing each engine, the total being more than 1500 hr., during which time the 189 coaches were each tied up from 6 to 10 hr. This indicates the possibility of installing demountable engines in future buses. Assuming that a demountable engine could be taken out and a new one substituted in approximately 3 hr., based on these 189 changes alone, a total saving of 933 hr. could have been effected if these buses had been equipped with demountable engines.

Brake construction is another item worthy of the consideration of the designer, engineer and manufacturer. I understand that in many cases brakes have to be relined after but a few thousand miles of service. The cost of relining a set of brakes on large equipment is \$40. Brake maintenance is therefore an important expense item. Braking efficiency on present equipment is satisfactory, but we are of the opinion that longer life could be built into brakes so that less frequent relining would be necessary.

Springs also are important. On one fleet of 154 coaches we were forced to make 307 spring changes in seven months; 252 were front and 55 were rear springs. This seems to indicate need for improvement in spring design.

Clutch assemblies are constantly in need of repairs and adjustments. A more rugged clutch should be developed to withstand the severe use given this unit under all sorts of conditions.

The future motorbus should incorporate many improvements in body construction. When we compare the light-weight "rattle-trap" buses of several years ago with the more sturdy designs of today, there seems little doubt of the advisability of increasing vehicle weight when it adds to operating efficiency and longer life. On the other hand, designers should not overlook the strides being made in the development and application of light-weight alloys and other materials in keeping weights within reasonable bounds. At present, some of the newer materials are undoubtedly too expensive, but increasing use will reduce these prices.

One of the present drawbacks in bodies is that the body posts, which usually are of ash, have a tendency to rot away within a period of two years due to damp or to dry rot. A body would last considerably longer and have much less vibration and squeaks if all wood parts were treated with some waterproofing material. It might also be advisable to reinforce wood body-posts with metal bands. A few bodies are now being constructed in this manner. Some authorities favor construction which incorporates rub-rails built in at belt lines and panel skirts to prevent damage to panels, window pillars and windows in case of side-swiping.

The matter of body heating and ventilating should engage attention. We must have adequate heat without drafts and without gas fumes, and good ventilation without road dust and dirt. This may require the adoption of a suction fan installed in the rear of

coaches. The problem of body rattles and squeaks seems well on the way toward solution, except for the noise incident to loose seats and seat-fastenings which have caused considerable trouble and expense. The problem of noise caused by seats lies with the seat manufacturer. Attention also should be given to the matter of leaking roofs. This is not so much a question of design or material as of carelessness in manufacturing and finishing.

Trends in Passenger-Carrying Capacities

For the last three years production of both city and intercity buses designed to carry 22 passengers and more has exceeded the production of units of 21-passenger capacity and less by a comfortable margin. We cannot overlook the fact that sales figures for the last few years indicate that the small-capacity job is not showing any tendency to pass out of the picture.

While the announcement of new models does tend to point the way to the thinking of the industry, nevertheless we feel that the safest course is to base our conclusion on the types of vehicle that actually have been sold. On this basis the 29-passenger-and-larger-capacity models unquestionably seem to be the leaders in the intercity field, with the 21-passenger coach in second place. In city service, the running headway is much closer. The 29-passenger type, which unquestionably was the leader in city service for the last five years, has stepped into second place and the 21-passenger type is slightly in the lead.

Sales figures, together with an analysis of current models, seem to indicate decided emphasis on the development of larger vehicles for long-haul intercity use. Units designed to carry 35 to 40 passengers have been available for some time. Now we have the 52-passenger model, which has been tried out with some measure of success in intercity service between metropolitan points where previous experience has indicated the need for frequent service and numerous doubled and tripled schedules.

Healthful Business Condition Noted

The foregoing current developments, together with experiments prophetic of the future, seem to indicate a more sympathetic understanding of the operators'

problems on the part of the manufacturer, his designers and engineers. This is a healthful condition. It reflects a spirit of cooperation that is essential to the progress and betterment of the industry. There is still plenty of room for improvements and some of these will no doubt be slow in making their appearance. From the viewpoint of today, no immediate radical changes of design seem to be in prospect. Experiments are under way with Diesel and steam engines, with cheaper fuels, and so on. It must be remembered, however, that the bus operators of America have a tremendous investment in gasoline-engine-powered equipment and in facilities designed primarily for the maintenance of such equipment.

The present type of gasoline engine has been greatly improved. Maintenance employes are well versed in its care. Unless some revolutionary improvement in the use of heavier fuels is developed, it is doubtful if they will make much headway in replacing the present type of powerplant so long as the price of gasoline remains at reasonable levels, and there is every indication that it will.

On the whole, it seems that bus design is showing substantial improvement in all phases. This is due in large measure to better understanding of bus requirements by both the manufacturer and the operator. Progressive operators are glad to make suggestions and to pass on to manufacturers the ideas and improvements developed by their companies. Bus manufacturers have been quick to appreciate the advantages of this "firing-line" information, and to incorporate such ideas when practicable. They are giving more thought than ever before to the details that mean a saving in time and money for the operator. In short, they are looking ahead with the industry rather than contenting themselves with the production of equipment on a "take-it-or-leave-it" basis.

The operator, on the other hand, is thinking of equipment purchases less and less in terms of price, and more in terms of quality construction, longer life and lower maintenance-expense. With this open-minded attitude on the part of the two interests concerned in the development of the bus, it is certain that improvement will be constant and that the next few years will witness a marked improvement in the design and efficiency of the motorbus.

Design Factors for Future Motorcoaches

By D. W. Russell²

IMPROVEMENTS which can be obtained by the solution of engineering problems that must yet be solved are emphasized by the author, rather than improvements that are available at present. The five particulars in which the motorcoach needs to be improved are design, safety, comfort, operation and maintenance. That the motorcoach be designed and constructed as an integral unit is advocated so that the design shall completely embrace every part which is to be installed in the vehicle. Elaborating this

thought, the author says that the job turned out by a company's manufacturing plant should be the company's design and handiwork. Every accessory should be planned and located by the manufacturer in the original design, to make certain that the operator gets a completely homogeneous unit.

After stating that the motorcoach must be made safer, the author discusses improvements that will tend toward greater safety. Among the vital needs stated are the use of materials of greater strength and better quality, headlights whose beams follow the direction of the front wheels around curves, better

² Southwestern Transportation Co., Texarkana, Tex.

location of the instrument board, and better planning for the installation of the electric wiring so that the danger from worn insulation will be minimized.

Cheaper operation of motor-vehicles is imperative, in the author's opinion. He suggests various ways in which cost reduction can be accomplished. Accessibility and standardization are discussed and instances

are cited to show that in some cases the need for greater accessibility is almost desperate. Practically the same statement applies to the need for standardization of parts.

In conclusion, the economics of motorcoach operation are touched upon, and a summary is made of the probable future requirements of coach construction.

A MOTOR-VEHICLE operator usually is so close to the trees that he cannot comprehend the forest; an automotive engineer is inclined to overlook the fact that a forest is merely a collection of trees. No operator is interested in the engineering viewpoint or in how well a vehicle performs on test runs made by engineers, assistants or testers. He is interested in how it performs on the highways with the drivers available; how safe it is to operate; how the passengers like it; whether it tends to bring repeat riders; how many road failures there are, and whether they are due to design, poor workmanship or poor materials; how cheaply it can be operated; how often it must be serviced; and how much per mile it will cost to maintain.

There are five particulars in which the motorcoach needs to be improved: design, safety, comfort, operation and maintenance. The very nature of my subject requires that I shall not confine myself to a discussion of improvements which are presently available, although I shall deal with such improvements in a large measure; but also in improvements which can be attained by the solution of engineering problems which are yet to be solved. Therefore, if I ask for the seemingly impossible, I do so only because I sincerely believe that automotive engineers can and will make it possible.

An outstanding improvement which is greatly needed and easily attained is that the motorcoach be designed and constructed as an integral unit. I do not mean necessarily that all or any parts be produced by the company which assembles it, but I do mean that the design shall completely embrace every part that is to be installed in the vehicle. Numerous parts are installed in motorcoaches as afterthoughts. In one coach, the gasoline tank was forgotten until after the coach was built. The result was that, for the available location, it was impossible to build a tank that could withstand the vibration and strain, or to change it in less than from 5 to 9 hr.

The situation is similar to that of an architect who designs a house without regard to the interior decorator or the landscape gardener. The job turned out by a company's manufacturing plant should be the company's design and handiwork, from the front to the rear bumper. Every accessory should be planned and placed by the manufacturer in the original design, to make certain that what the operator gets is one complete homogeneous operating unit.

Needed Motorcoach Improvements

The motorcoach must be made safer. Great strides in this direction have been made within the last few years, but much remains to be done. A vital need is greater strength and better quality of the materials used. These vehicles operate at high speeds and operators carry the responsibility not only for the lives of the thirty or more passengers carried but also for many

other motorists on the road. Strength and quality should not be sacrificed for reasons of either cost or weight. Headlights are far from perfect. Lamps are needed which will completely light the road for at least 500 ft. ahead, which will follow the direction of the front wheels around the curves and, above all, which will penetrate fog and at the same time will not glare or interfere with a driver coming in the opposite direction.

The instrument board is so located at present that the driver must divert his eyes from the highway to check his speed, oil, gasoline and ammeter. An instrument board located so that drivers can see it and the road at the same time is needed. Great improvement has been made in brakes, in the last few years, but we need reliable brakes which will be both foolproof and accident proof. Gas fumes from the engines still invade our coaches; occasionally, the deadly carbon monoxide also gets in and causes terrible results. The possibility of having engine-exhaust fumes enter a coach should be eliminated permanently.

Frequently, during the winter, windshields are made opaque by sleet, and operating men have resorted to numerous home-made devices to overcome this hazard, some of which have been partly successful. The problem, however, is an engineering one and an early solution is urgently needed. With the increased use of electrical appliances on the coach, the danger from worn insulation has been greatly increased. Entirely too much haphazard installation of electric wires exists. Not only should this defect in design be corrected, but some efficient and permanent means of insulation should be developed.

Engineers have gone relatively further toward making the motorcoach comfortable than they have in making it safe or economical. I can find but three particulars in which improvement is needed. One great advantage which the motorcoach has over the rail car, and particularly that of the local train, is the smoother and less jarring ride. However, we find that considerable discomfort still remains due to jars, jolts, rough roads and sudden application of brakes, which should be reduced by better design and possibly by completely suspending the body from the chassis. Engine noise should be further reduced, if not entirely eliminated. Interior lighting is one of the most serious difficulties. An interior light which will not cast a glare on the windshield is urgently needed. The present devices are entirely unsuccessful. Individual seat-lights strong enough to permit the passenger to read in comfort, without disturbing the nap of his neighbor, are desirable.

Cost Reduction Is Imperative

We must have a motor-vehicle which is much cheaper to operate than are the present models. At present, designers make us propel 4 lb. of vehicle for each 1 lb. of passenger that we carry. A magnificent field for operating economy lies ahead. Other industries are con-

stantly seeking lighter alloys; therefore, let war be waged on excess weight and parts, without, however, sacrificing strength at any point. A further way in which the tare ratio can be reduced lies in reducing or eliminating the space used for fenders and the like and utilizing this space for payload. The conventional hood wastes a large amount of the length now allowed by State laws.

While the engine is being moved to a less expensive but equally accessible location, consideration might also be given to reducing the length of the drive line—perhaps to complete extinction—and thus attain the operating economy which comes from a more direct application of power. The interest of rail carriers in motor-vehicle operation is increasing. It is but a question of time when their ownership will dominate the field. Their use would be greatly accelerated should a coach be made possible which would operate on either rail or highway with facility and safety.

Motor-vehicle units should be designed with more mileage between servicings in view. We cannot operate a given model with a minimum of 1000 miles between servicings of any kind except sweeping out with a broom. We run some of these vehicles 900 miles without a lay-over exceeding 30 min. They are greased, minor adjustments are made, and they are run an additional 900 miles. It has really been amazing to see how much cheaper these vehicles operate than those that require greasing and numerous other attentions after 250 to 400 miles. I hope this is but the beginning of a lengthening in the runs between servicings.

Give consideration to brake servicings; usually, we must adjust brakes every few hundred miles, and this is very many times in excess of similar adjustment on rail cars. Further, expensive replacements are frequently necessary although the linings themselves are worn less than 50 per cent. We are looking to automotive engineers to produce a vehicle which will either eliminate all tire changes on the road or vastly facilitate them—particularly those for inside dual rear-tires—reduce the present waste of time and labor, and put less strain on the passengers' patience.

Accessibility and Standardization Needed

The objective of the design must go much beyond producing a vehicle which will operate safely, comfortably and cheaply. It is only a question of miles or time until every part of a motor-vehicle must be removed for replacement or adjustment. On many present coaches, while the idea of accessibility may have been in view at the start, it was wholly lost sight of before the vehicle was completed. The design should make it possible for us to inspect, remove and install all parts quickly. We are rapidly approaching the time when we will cease tying up the entire vehicle to repair any part. Lack of accessibility and the costliness of removal and reinstallation of parts is by far the most severe indictment that can be drawn against the present motorcoach.

I have in mind one vehicle on which it has been found that the most economical way to pack the water pump is to remove the engine. On another vehicle it is more economical to remove the engine than it is to attempt to change the generator while the engine is in the frame. On one vehicle we were told by the manufacturer that it would require about 2 hr. to take out the power-unit assembly. We found that it could be done in 1 hr. and 35 min., provided that 4 hr. were spent in removing the dash. To take out shackle bolts we find one vehicle on

which it is necessary to loosen one end of the springs and everything pertaining to the rear assembly, then to pull the axle forward until the shackle turns over and drops down below the frame.

And then, how desperately we do want engineers to standardize parts! Recently our railroad purchased ten large locomotives, entirely different in design and power from any it then owned. The number of parts of this locomotive which were interchangeable with locomotives that had been in service 5, 10, and even 20 years was amazing to me. To put these modern locomotives in service and properly maintain them, the railroad was required to add but one-fifth the number of items that we would have had to add if we had put into service two new motor-vehicles of any make which were of a model one year later than others of the same make already in service!

One operator purchased vehicles primarily because the sales department assured him that these units had the same type of engine, transmission, differential and front axle used in other vehicles which had been purchased by the department less than six months before. After the vehicles were received, it was found that the engine was interchangeable after making some \$400 or \$500 worth of changes and changing frames; that by making \$100 worth of alterations the transmission was interchangeable; and that by doing a rather large machining job the rear assembly was interchangeable. The only interchangeable parts of the front axles were the bearings on the spindles. It was found that an entirely different steering-gear was used. With the exception of the steering-gear, one of these units today is interchangeable with the older ones—engine, transmission, rear assembly, drive line and front axle—and the amazing part is that, although equipped with the old-type assemblies, it is the most economical unit of that group.

Economic Operation Essential

Each motorcoach represents a substantial investment. Therefore, the final essential in a motor-vehicle is economy in operation, servicing and maintenance rather than cheaper first-cost. The carriers by motor-vehicle are gradually merging into a relatively few large companies, many of which are directly or indirectly connected with the rail carriers. This will tend to be more and more the case. The great hue and cry raised by the railroads today over busses and trucks could have been largely averted had the railroads availed themselves of this transportation, coordinated with their old form of transportation, before someone took the opportunity away from them. These larger companies know that greater economies can be realized in operation and maintenance than can be realized in fixed charges. In my judgment the vehicle so designed will be a far more profitable investment than one designed to meet a price.

We want the best material and highest quality in motor-vehicle parts. By replacing the makers' bodies with bodies made in our own shops, we have quadrupled their life. In one month our company had 43 road failures attributed to failure of fuel-feed systems. Two different manufacturers told us that they were using the best materials the market provided, that they were buying them from someone else and could do nothing about it. In our business, when we contract to move a passenger or freight from origin to destination, we are expected to deliver to destination even though there be flood, fire or tornado. I feel that the vehicle manufac-

turer should hold his designing engineers responsible for the satisfactory performance of all parts of the vehicle, and that we as operators have a right to look to the manufacturer for satisfactory performance from every part of a vehicle we purchase.

On another group of vehicles we found that, to hold the hoods on, we had to take off the original hood-clamps and replace them with hood clamps manufactured by another company. There was no way to hold these hoods up when mechanics were working on them; it being necessary to lay them over the other side, which split the hoods and ruined the paint. Of course we have been able to correct this but, primarily, our business is to handle persons and property, not to complete motor-vehicles.

Public regulation of an increasing rigidity lies ahead of us. Competition with other forms of transportation, and particularly with the privately owned automobile, is daily growing keener. The rail carriers are considering drastic reductions in their rates. Our transportation costs, as well as maintenance costs, must come down if we are to survive. The only thing that can save us is economical operation that will allow us to furnish the most economical form of transportation to the traveling public.

That automotive engineers can and will solve these problems, I have not the slightest doubt. When I recall the vast improvement in design, safety, comfort, speed and appearance which they have brought about in the last decade, these present-day problems look far less insurmountable.

Summary

The future requirements in motorcoach operation are for a vehicle which is:

- (1) Designed and constructed as an integral unit
- (2) Safer because:
 - (a) The strongest available materials are used
 - (b) The headlights are made brighter, non-glaring and fog penetrating
 - (c) The instrument-board and road are visible at the same time
 - (d) The brakes are both foolproof and accident proof
 - (e) There is no possibility of danger from fumes or carbon monoxide
 - (f) The windshield is sleet-proof
 - (g) There is no possibility of short-circuiting the electric wires
- (3) More comfortable because:
 - (a) All jolts, jars and jams are eliminated
 - (b) All noise is eliminated
 - (c) The interior lighting is strengthened, but individualized
- (4) More economical to run because:
 - (a) The tare weight is greatly reduced
 - (b) Passenger space is increased
 - (c) The power is applied directly instead of through the transmission line
 - (d) Either the highway or rails may be used as a roadway
 - (e) The necessity for lubrication or servicing on the road is reduced or eliminated
 - (f) Tire changes on the road are eliminated or are vastly facilitated
- (5) More economical to maintain because:
 - (a) All parts can be quickly inspected, removed, exchanged or installed
 - (b) The parts are standardized
 - (c) Only materials and parts of the highest quality are used
 - (d) Brakes, fuel feeds, and generators are adequate and accessible.

The Discussion

FOLLOWING the remarks of Chairman Warner Tufts of the National Association of Motor Bus Operators, which precede the discussion, several opinions of the trends in types and sizes of motorcoaches are expressed. The present status of headlamps is explained, and the use of reflectors by means of which the signal is given by the reflected light from the headlights on other cars is advocated as an excellent supplement to present lighting equipment.

Comparisons are made between the characteristics of the work of city operators and intercity operators,

since these constitute two definite groups into which the bus business is divided and they have different requirements to meet. The opinion is expressed that the tendency will be toward smaller and smaller buses, even to a capacity as small as five or seven passengers. Numerous factors which handicap the development of the bus industry are cited, the opinions of Pacific Coast operators as to future needs are stated, and a somewhat detailed citation of present motorcoach problems is made. In conclusion, free exchange of operating-cost figures is advocated.

CHAIRMAN WARNER TUFTS:—You have gathered here to investigate the Future Needs of Motorcoach Operators. That you have selected this particular subject for this session indicates your belief that motorcoach operation has a future. And so I take considerable pride in the fact that you have selected me to act as your chairman, because I too have an abiding faith in the future of the bus business.

I came up from Washington by train. That train with its locomotive and various cars weighed approximately 2,030,000 lb. It carried something less than fifty passengers, which seemed to be about a normal

load. This transportation service required the movement of 40,000 lb. of machinery per passenger accommodated. The average private automobile with its average load requires 1650 lb. of machinery per passenger; the average bus requires only 1133 lb.

The railroad is the oldest means of transportation of the three. The private automobile is newer. The bus is the newest. Perhaps there may be some significance in this plain historical fact. I have used the term "oldest" in its sense of maturity. I wonder if it may not also be interpreted in this connection as meaning antiquated. But to you, who are familiar with these facts of motorcoach operation, I need give no stronger proof of my confidence in the future of the bus business

^{*} National Association of Motor Bus Operators, City of Washington.

than the simple fact that I am in the bus business, that I came into it deliberately, and that I propose to remain.

We, in the National Association of Motor Bus Operators, have an opportunity to examine Nation-wide conditions. We miss many of the practical details of operation, yet I believe we get a comprehensive picture that is rather unique. We find that the problems of the motorcoach operators are many and very real, but I think none of these real problems are inherent. In the main, they can be divided into two groups. The first group is caused by the presence of the motorcoach in a vast and complicated system of social checks and balances. Society is not wise enough to maintain in equilibrium all of these different and conflicting forces all of the time. The motorcoach is not only a competitor of other means of transportation, but it is a public-service agent. Whether or not it is continually serving the public to the best advantage of the public and to its best capabilities as a vehicle of transportation presents many problems. The fact that it may or may not take business away from other means of transport also creates problems. On the whole, I think that the motorcoach operator is handling problems of that particular nature as wisely and as intelligently as those problems are being handled by any other public-service enterprise.

The other group of motorcoach problems is composed of those due to the inherent limitations of the vehicle. But it seems that, as the demand arises, automotive engineers are able to bring forward the solution and, on the whole, we must leave these physical problems to them.

In the ensuing discussion I should like you to bear in mind that we must make certain assumptions. Let us assume then that the social limitations of which I spoke are all taken care of. Let us assume that the relationship of the motorcoach to other means of transport is a perfectly free relationship and that, when we have decided what the solution to our problems should be, the public will cooperate with us. I think that this is the fairest way to look at this question because, in the long run, that situation which is economically and mechanically justified is the situation that will prevail.

H. B. HEWITT⁴:—Considerable development work has been done with regard to wood preservative. A number of taxicabs which we purchased in 1929 were treated with a wood preservative which was recommended to us as having been used on trolley cars that are operated along the seacoast, inasmuch as the operating company found that it was able to double the life of the wood used in their construction by using this preservative. These taxicabs have been carefully examined from time to time and we have found positive evidence of the effectiveness of this preservative. We adopted it early in 1928 for all motorcoach wood-repair operations, treating each wooden part with the preservative. Since then, motorcoaches which have been damaged by accidents have proved that dry rot is retarded in the wooden parts treated.

Trends in Types and Sizes

A. S. MCARTHUR⁵:—The future of the motorcoach is certainly assured, even in the smaller operations in

Canada. No doubt the future development in Canada will follow the development made in the United States. Some of our problems perhaps differ from the average problem in the United States on account of road conditions, climate and the like, but on the whole the operation requirements are such that a coach which is satisfactory in the United States should give satisfactory performance in Canada.

The trend of the size of vehicle has been interesting. As yet, with a few exceptions, we have not the larger units in Canada, even in city operation, although it may be that this use of larger units will follow. As Mr. Walker pointed out for city operation, if the motorcoach of smaller capacity is now taking the lead over the 29-passenger vehicle, it is an interesting trend which will be watched by all operators, particularly by those who operate two sizes of vehicle as we do. We have both the 21 and the 29-passenger vehicles, for city service and also for the service between Toronto and Buffalo.

H. C. EDDY⁶:—In New Jersey at present we have about 4000 motorcoaches engaged in intra-State operation and somewhat more than 1400 in inter-State service. Although New Jersey is one of the smaller States, I believe that more motorcoaches operate in and through it than in any other State. This perhaps is due in large measure to its geographical location between Philadelphia and New York City.

Regarding the present requirements of the motorcoach operator, it might be said that they are for a coach that will provide service that is satisfactory to those who ride. I am glad to note that Mr. Walker emphasizes the need for satisfying the passengers. Although the economy of operation and the maintenance costs are important factors, the satisfaction of the rider is paramount on account of the competition not only with the privately owned automobile but with other forms of transportation. To get all of the riders, a motorcoach must be designed to suit their requirements.

The design of motorcoach bodies is of particular interest, and I wish that Mr. Walker had treated this subject in greater detail. The New Jersey specifications are perhaps somewhat more comprehensive than those of any other State, and we are very particular about requiring the body to be designed to meet certain requirements. Head room, knee room, width of aisles and accessibility of the rear door have all been improved in the last few years. The early motorcoaches were not what they should have been and, although they have been improved upon in the last several years, there is room for further improvement.

The New Jersey Code specifically reads: "An emergency door located in the center rear or otherwise, as the Board may direct, shall be provided." We have interpreted this rather liberally. In the city-service motorcoach we require a center door, but in the parlor-car type ordinarily used in inter-State service we allow the emergency door to be located at the rear on the side. The design of many of the motorcoaches has made it difficult to gain access to that rear door. Although this inaccessibility has been overcome considerably, there is opportunity for further improvement. Regarding the question often asked: "Who uses the rear door anyhow?"; usually nobody uses it, but nevertheless it must be provided. If the passengers do not use it, it is their fault. Therefore, the emergency door should be made accessible.

The statement, "21-passenger-capacity type slightly

⁴ Engineering assistant to vice-president of operation, Mitten Management, Inc., Philadelphia.

⁵ M.S.A.E.—General superintendent, Toronto Transportation Commission, Toronto, Ont., Canada.

⁶ M.S.A.E.—Traffic engineer in charge of street transportation department, Public Utility Commission, State of New Jersey, Newark.

in the lead" is surprising. I do not know whether the tendency will be to use the small motorcoaches for city-type service or not. Since the street-railway and motorcoach companies are handling mass transportation with the large-sized unit when they compete with the trolley car—and I do not say whether that should or should not be done—it seems to me that, to handle mass transportation satisfactorily, the larger motorcoach having greater seating capacity and a correspondingly large standee capacity is quite essential.

In regard to Mr. Walker's statement that "more thought is given than ever before to the details which mean a saving in time and money for the operators," this should of course be true. But more time also should be given to the design of the motorcoach, concerning which much of the success of the operating company always depends. Therefore, comfort and general attractiveness to the rider are important, especially in these days of competition with the privately owned automobile and other means of transportation.

F. F. CHANDLER¹:—Regarding Mr. Walker's discussion and analysis of the costs of operation, I should like to have information relative to the salary costs of drivers, because it seems to me that ease of operation of buses can easily be reflected in a saving of cost on account of drivers if the labor of operation can be reduced. When riding in buses I have particularly noted points about steering and gearshifting. As to the latter, the driver simply has to wait and judge by his own experience whether the gears will mesh or not. The labor involved in driving these vehicles is a large item, especially in city traffic, which requires a great amount of gearshifting. It would be interesting to know how many hours a driver can perform that job without undue fatigue. This also involves the subject of safe driving. If operators require a driver to do expert work for hours longer than he is capable of withstanding physically, the lives of the passengers are certainly being endangered.

In our company we are thinking on the subject of steering motor-vehicles, and thinking intensively, while bearing in mind the foregoing points. Many of the vehicles are becoming larger and larger. Do present types of steering equipment fill the bill? If they do not, what type must be provided? Certain limitations exist in the design of steering equipment because, as the vehicle increases in size, the steering load necessarily increases in proportion. If the vehicles become larger, the ratio of reduction, that is, the additional mechanical advantage that the driver must have available, may increase to the point at which steering is slowed up to such an extent that the actual steering movement of the vehicle cannot be accomplished quickly enough to afford safe driving. Therefore, is auxiliary booster equipment needed in steering the vehicles to modify the driver's labor, and is the use of auxiliary equipment to aid in gearshifting needed?

I recently drove a motor-vehicle which was equipped with a so-called semi-automatic gearshift which natu-

rally progressed through first, second and third speeds automatically with movement of the clutch pedal.

Present Status of Head-Lamps

R. E. CARLSON²:—Mr. Russell mentioned that he would like headlights which would enable the drivers to see 500 ft. ahead. At present, we have lighting equipment which will meet these requirements. The ability to see a given distance ahead depends, among other things, upon the amount of light available and the aiming of the headlight beams. Many States have regulations which, particularly in the case of passenger vehicles, require that the beams be aimed below the horizontal with the vehicles empty so that, when the vehicles are loaded, light will not be thrown above the horizontal. While this practice of aiming the beams below the horizontal minimizes glare, at the same time it materially reduces the visibility distance for the driver.

With the present type of depressible-beam equipment, whereby an upper beam is provided for high-speed driving and a lower beam for passing or for city use, it is possible to secure a good and safe driving-light and at the same time to minimize glare by using the lower beam when meeting other vehicles. The question as to whether or not higher aiming of the upper beam represents good practice is dependent somewhat upon the attitude of the drivers. It is obvious that unless the lower beam is used regularly to reduce the glare, a higher aiming of the upper beam or a higher aiming of a beam from a single-beam head-lamp will increase glare.

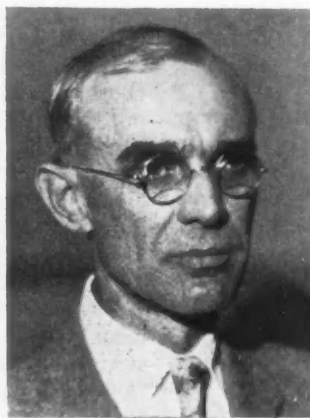
Bulbs having greater candlepower are now available and are legal in most States. These larger lamps permit wider spread of beam, at the same time maintaining the necessary intensity to provide a good high-speed-driving light.

Regarding dirigible lights which are interconnected with the steering mechanism, these are available at present as auxiliary lights. I am not sure that dirigible lights used alone would be very satisfactory; but, when used to supplement the present type of headlight equipment, they are extremely useful.

There is a trend toward the use of two rear lights and two signal lights. I think that this is a step in the right direction and should result in added safety on the road. Reflex devices made of glass, or reflectors, have come into use, and the signal is given by the reflected light from headlights on other cars. These devices have been used as markers and, in combination with incandescent lamps, as tail-lamps. The Society has lately developed a specification covering laboratory tests of these devices; in general, the indication obtained from them is not sufficient to warrant their replacing signal devices using bulbs, but they are an excellent supplement to the present lighting equipment. I feel that their use should be encouraged, particularly in marking the sides of vehicles so as to give added safety at street intersections.

City and Intercity Operators Distinguished

CHAIRMAN TUFTS:—I classify the bus business into two definite groups, the city operator and the intercity operator. The characteristics of their work are quite



F. F. CHANDLER

¹ M.S.A.E.—Vice-president, Ross Gear & Tool Co., Lafayette, Ind.

² M.S.A.E.—Commercial engineer, Westinghouse Lamp Co., Bloomfield, N. J.

different. I think the tendency of the intercity operator will be to use larger and larger buses and to supplement them by smaller buses of 21-passenger capacity or less. The intercity operation of several years ago almost invariably provided touring cars to carry the overload traffic at times when it was uneconomical to run a larger vehicle and I think that tendency will continue. It is more economical to fill one large bus with passengers in New York City and run it through to Philadelphia than it is to run two smaller buses. At the same time, however, we are reaching very definite limits imposed by the strength of the highway on which the vehicles operate. Many facts about highway strength are not yet understood, and the legislation on the subject is based largely on indefinite data and upon what laws the enemies of highway transportation are able to enact. I think the tendency will be to regulate wheel loads rather than vehicle loads, which means that laws will permit larger buses if they operate on six wheels instead of on four; but definite difficulties exist in installing six wheels on intercity buses.

In city operation the origin and destination needs of passengers seem to tend toward greater flexibility. Perhaps New York City is somewhat indicative of the trend with regard to the Country as a whole. A bus which can carry fifty passengers or more must hold up and delay its entire load to accommodate only one passenger who may be getting off or getting on. In New York City, cross-town or feeder traffic is a very important factor, and I imagine that in this and some of the other larger cities the tendency will be toward smaller and smaller buses, even to a capacity as small as five or seven passengers.

R. E. PLIMPTON⁹:—Regarding five or seven-passenger buses, some of that light-service operation is evident throughout the Country. A large number of passenger-car chassis and light-weight-truck chassis operate in such service and are not reported in the ordinary statistics. Especially in agricultural districts where the roads are poor, the small vehicle seems to be favored.

Development Is Handicapped

A. J. SCAIFE¹⁰:—The growth of the bus industry has been very rapid, but it is handicapped by legal restrictions and by pioneering. It is very difficult for a manufacturer to produce a perfect vehicle and to pioneer at the same time. However, during the last five years progress enough has been made so that some attention can now be paid to refinement of details and easier servicing. Very recently we were satisfied with 40,000 miles as the maximum period between complete overhauls. In some units that mileage has been exceeded and in others it has not been approached. For example, it has been said here that the brakes on some buses needed to be relined after 600 miles of service, which is far from being satisfactory, especially when considering the 100,000-mile complete-overhaul requirement at which we are now aiming,

Designing engineers today are paying greater attention to the operators' requirements than they did several years ago, because they now have time to consider some of the operators' demands. As brought out by Mr. Russell, the changes in the models have been made so rapidly that the engineering departments of the different companies have not had time to perfect the vehicles on which they were working before they were forced to design new vehicles. I am not sure that the same argument does not still hold true with regard to powerplants.

Concerning greater sustained speeds, the vehicles are fairly close to the maximum speed allowed and needed for today. A greater sustained speed is demanded and that will obviate some of the gearshifting; but with larger powerplants the problems relating to transmission increase and shifting become more difficult because the transmission must be constructed with much heavier parts of conventional design, which makes a more difficult problem from the viewpoint of the operator. However, by using the larger powerplants, it may be that less shifting will be required and, while shifting may be harder, it will be less frequent and therefore not so objectionable. With an engine of the conventional design and a rating of more than 150 hp., the clutch becomes a very serious problem unless a more satisfactory type can be developed than that used at present. The rear-axle problem is not so serious, but the axle will increase in weight in proportion to the torque of the engine installed in the vehicle.

Some persons may think that the designing engineer is not giving as much attention to the operators' demands as he should, but I know that he is giving very careful consideration to the needs of the operators with reference to present and future requirements.



A. J. SCAIFE

Opinions of Pacific Coast Operators

E. C. WOOD¹¹:—I have been instructed by the motor-coach operators on the Pacific Coast to state their opinion that, as perfect as the chassis and engine design may be at present, they are hoping for further refinements and improvements because the improvements they have suggested naturally will tend toward greater economy in operation, reduce repairs and operating costs, and result in longer life of the vehicles. Constant study should be directed toward obtaining a better balance in the life of the various parts that constitute the vehicle. This no doubt will be obtained through increasing the factor of safety of the parts which have shorter life. There is yet much room for improvement in the accessibility of wearing parts so that replacements can be made in the shortest possible time. The nature of these improvements will be determined by improving the designs of the brackets and supports that hold these replacement parts, since they have considerable influence on their accessibility. There seems to be a general opinion among the engineers of these operating companies that more development work should be assigned to the operators in the field.

F. C. HORNER¹²:—With reference to the necessity for carrying spare equipment to the extent of 25 per cent, this subject constitutes a very serious problem for the operators. This necessity will be modified to a

⁹ M.S.A.E.—Transportation engineer, White Motor Co., Cleveland.

¹⁰ M.S.A.E.—Consulting field engineer, White Motor Co., Cleveland.

¹¹ M.S.A.E.—Superintendent of transportation, San Francisco Division, Pacific Gas & Electric Co., San Francisco.

¹² M.S.A.E.—Assistant to vice-president, General Motors Corp., New York City.

considerable degree as progress is made in perfecting motorcoaches and motor-trucks, in which operating fields this is a common problem. It is perhaps not so serious for the motor-truck operator, because he can delay non-perishable freight somewhat without experiencing serious consequences, but the delay of passengers causes an immediate unfavorable reaction that will create ill will toward the operating company if the practice is continued.

Various Difficulties Cited

B. B. BACHMAN¹²:—I have fundamentally grouped comfort—with which I include satisfaction and safety—and maintenance. Speed of transportation is not necessarily a factor of comfort; but it is a desirable characteristic and one which the operator must have to provide satisfactory service that he can sell to the public. I should like to couple that distinction with maintenance and operating cost.

An unavoidable unfavorable relationship with regard to operating costs, as between the highway vehicle and the rail vehicle, has been intimated. It is desirable to establish an ideal which can be or should be attained, so that we may have a comprehensive idea of what the problems are and the fundamental differences which exist at present and constitute difficulties which must be overcome. One very fundamental difference has reference to the coefficient of adhesion between the wheel and the surface upon which it operates. The accelerating and the decelerating forces available are direct functions of this coefficient.

For example, the question of brake life has been raised, but has anyone considered the fact that what would be an emergency stop for a railroad train is a service stop or a service-brake application for a motor-vehicle? The reasons are, first, that it is possible to make an emergency stop because there is sufficient adhesion between the wheel and the surface on which it runs. Second, it is necessary because the gradients are considerably greater and advantage of the adhesion factor must be taken. In addition, there are interferences in operation on the highways that do not at present pertain to the railroad because the train dispatcher has control of the operating schedule and the motor-vehicle operator does not. Signal lights are provided on the highway and also on the railroad, but those on the railroad are tied in with the schedule as a safety measure.

An ideal operation would be one in which the signal lights would not operate. In other words, there always would be a clear track; whereas, the signal lights in our cities seem to be based on the establishment of maximum congestion. The vehicle must stop suddenly because, to keep moving, the driver will try to beat the traffic light and therefore does not stop until the last moment. This calls for emergency operation at frequent intervals, without considering the driver whose vehicle comes out of a side road which is not equipped with a traffic light, and who pays no attention to "stop" signs or other means of traffic regulation; also, to the driver who cuts around in front of

other vehicles. On the other hand, after a vehicle has slowed down or stopped, it must pick up speed again and the coefficient of adhesion affords the possibility of utilizing greater accelerating forces which are taken advantage of to the maximum extent. This advantage has not yet been utilized but, unquestionably, it will be.

The fundamental difference mentioned starts a train of events. It affects brakes, gearing in the rear axle, the transmission, the clutch and the powerplant. Mr. Scaife has advanced the idea that we need to attain greater sustained speed. In my opinion, only two ways exist by which this can be done. One is to have a clear track, to arrive at a certain speed, and then to maintain that speed. This obviously is out of the question, because we do not have control of the influential factors. The other method is to take greater advantage of the accelerating forces and pick up vehicle speed more rapidly, also sustaining this speed on gradients, which necessitates greater power. Larger powerplants would therefore be needed unless some method can be devised whereby an automatically changing gear-ratio that will provide an automatic over-drive can be used so that, on level roads, the full power of the engine can be utilized at a higher gear-ratio than is available at present. It is a complicated subject.

Those engaged in the design of vehicles see the foregoing possibilities, but it is difficult for manufacturers to accomplish the compromises needed to harmonize the conflicting factors unless they have the assistance of the operators. Some manufacturers might say that Mr. Russell's criticism has been unduly severe, but I think he has not been severe enough. Some of the examples of faulty design he cites are inexcusable except that the development has been so rapid that it became a human impossibility to cover all of the details. No man or organization can waive a magic wand and overcome all the difficulties immediately. Highway transportation is relatively in its infancy. Automotive engineers have tried to do some things which they might not have tried if they had analyzed



B. B. BACHMAN

them in the light of cold facts, and the industry probably would not then have progressed to its present status. Some adventurous souls have seen the possibilities of a profit in the business, and have forged ahead faster than engineers with their slide rules have been able to travel.

The desirability of interchangeability of parts and units is so evident that it needs no amplification; but, on the other hand, when the requirements demand radical changes in structure, it is not unthinkable that the designer will conclude that the elimination of interchangeability is the least of a number of evils. For a given vehicle, if the distance between the longitudinal supports for the engine on the chassis is 40 in. and it is desired to increase the engine performance 50 per cent, the designer is faced with the following problem. If he keeps the length of the engine within 40 in., this means a sacrifice of bearing size which is a desirable fundamental. I believe that no present-day designer of experience will hesitate about getting adequate bearing size for the engine rather than interchangeability.

¹² M.S.A.E.—Vice-president of engineering, Autocar Co., Ardmore, Pa.

He knows that interchangeability is desirable from the operators' viewpoint, but he also knows that the requirements for the powerplant are paramount.

Transmission Road-Tests Made

A. F. DENHAM¹⁴:—As an example of what can be done in substituting transmission flexibility for engine horsepower, I cite a recent experience with a truck having a rated gross load of 20,000 lb. This particular model was equipped with a six-cylinder $4\frac{1}{8} \times 5\frac{1}{8}$ -in. engine, governed at 2000 r.p.m., which is not particularly large for this size of vehicle; in fact, the standard engine in this truck has a bore $\frac{1}{4}$ in. larger. The truck was equipped, however, with a five-speed single-lever-control transmission, with the ratios for the five speeds arranged in almost perfect geometrical progression. In addition to a decrease in engine size, the rear-axle ratio had also been dropped from 8.3:1 to 4.6:1.

The idea was to try what could be accomplished with a transmission designed for exceptionally easy shifting. In the particular transmission used it was possible to shift without declutching, through a ratchet design which was incorporated in the sliding dog-clutches for the engagement of the constant-mesh herringbone-gears used in this transmission. This was worked out so that engagement could be effected only when the engine had been brought up to synchronous speed with the propeller-shaft in the ratio of the gears to be engaged. The design also permitted manual free-wheeling by throwing the shift lever into neutral, also without declutching.

A manifold-vacuum gage was installed in the front of the cab, and it was interesting to observe the few instances under normal driving when anything near 100 per cent of the available torque was actually in demand. At 50 m.p.h. on a level road, the gage indicated that only 50 per cent of the available torque, roughly speaking, was being used. This speed corresponded with the governed speed of the engine, making a comparison fairly simple. The manifold gage read about 50 per cent of what it would have been when running against the governor without load.

In this truck the relation of gear-ratios in the transmission had been worked out so that, for logical operation, the engine would be working at practically all times between the speeds corresponding to the peaks in the torque and the horsepower curves. The fuel-consumption curve had also been worked out so that the minimum fuel-consumption was theoretically always obtained at these speeds.

The highly satisfactory performance of this truck without a complicated gear-change mechanism and with a fairly conservative engine size could not but help to impress the driver with the possibilities inherent in transmission or gear-change improvements in the direction of lowering ton-mile costs. It seems to me that the argument and the example are equally applicable to motorcoach work.

¹⁴ Field editor, Chilton Class Journal Co., Detroit.

¹⁵ M.S.A.E.—Engineer (operation and maintenance of automotive equipment) American Telephone & Telegraph Co., New York City.

¹⁶ Supervisor of motor equipment, The Atlantic Refining Co., Philadelphia.

F. K. GLYNN¹⁵:—What Mr. Russell and Mr. Walker have stated in their papers is equally applicable to the motor-truck field. What they have said is necessary in an engine for motorcoach operation is also necessary for truck operation. Their statements regarding interchangeability, maintenance savings and easier riding for the loads carried, are applicable also. Therefore, I find my interest in these papers fully as great as that of any motorcoach operator.

Exchange of Operating-Cost Figures Advocated

J. G. MOXEY¹⁶:—The thought expressed by Mr. Walker of a 25-per cent bus-transportation equipment-reserve was quite alarming. The large freight-transportation fleet represented by the petroleum industry has been, and can be, operated on about a 3-per cent reserve. I know of one fleet covering rather a large area that is operating on practically no reserve; in fact, the reserve is only a fraction of 1 per cent.

The interchangeability of parts or units was discussed, but another thought that I want to leave with the designing engineers from the operators' viewpoint is that of the interchangeability of replacement parts within the unit which brings about the modernization of that unit and is vitally essential to its long life and, therefore, to the economic use of machinery in the transportation business.

Much has been said about over-sizing, and about larger vehicles. Where are we to stop? We just about get equipped with vehicles under one set of regulations when the railroads step in and, by some twist of traffic schedules, or, as in a particular case, the establishment of switching charges in lieu of freight rates, they eliminate that particular type of vehicle from its activity so that the business reverts to the railroad. Along comes a truck manufacturer who builds something bigger and better. Again the motor-vehicle pushes the railroad out. That is based on practical experience. Now we want to know what the railroads are going to do? Recently I heard of a particular truck which had two engines installed side by side, being driven with individual rear axles and capable of hauling something over 100,000 lb. at rather high speeds.

I want to make a plea to the manufacturers and operators, particularly to the latter, of exchanging mutual confidential operating costs. I had occasion recently to go rather deeply into a particular hauling problem in which I requested from various manufacturers of trucks a set-up of operating costs on four wheels; six wheels; four wheels and trailer; six wheels and trailer; tractor and semi-trailer; and tractor, semi-trailer, and trailer. Naturally the big item that we all look to is the repair costs per mile. The replies from those various manufacturers showed a variation of as much as 400 per cent between the topnotcher and the low man. How many unwittingly are being drawn into undertaking a large transportation problem based on the manufacturers' set-up costs, based presumably on known operating information? Let us be more open, free and frank in the discussion of our actual basic operating figures, and let us not hesitate to exchange what those figures are and how the set-up is determined in establishing those unit costs.

Combustion and Design Problems of Light High-Speed Diesel Engines

Discussion of E. F. Ruehl's Annual Meeting Paper¹

MORE attention must be paid to light-weight design and to flexible combustion control if the Diesel engine is to become a serious competitor of the gasoline engine. The relative merits of existing types of combustion-chamber and injection systems used in present commercial four-cycle engines are discussed, and it is shown that the single-turbulence-chamber type offers the most promising means to high mean effective pressures at low fuel consumption. Stock high-pressure fuel-pumps and injection-valves, produced in volume by specialists, will have a great influence on the production of high-speed Diesel engines. The interrelation of combustion and injection processes in controlled-turbulence combustion-chambers is explained, and design details and test results are given of the practical application of single-chamber principles and of a stock injection system to flexible combustion control in a recently developed high-speed four-cycle engine.

Factors limiting mean effective pressure and piston speeds are discussed, as are also the mechanical problems of design, cooling and lubrication of vital parts. In comparing Diesel-engine with gasoline-engine weights, due allowance is made for the difference in maximum gas pressures.

The illustrations show examples of various combustion-chamber designs and design details and photographs of De La Vergne high-speed engines.

OLIVER F. ALLEN²:—Mr. Ruehl is to be commended for his conservatism, in contrast to the unfortunate tendency to rate Diesel engines on the basis of their maximum performance without reserving those margins which are essential for long life and low upkeep, especially in the case of engines operating at high rotative and/or piston speeds.

Something might be said in regard to supercharging to supplement Mr. Ruehl's paper. Supercharging has been employed in air service for about 15 years and for land service, especially at high altitudes, for at least 5 years. It has been applied successfully to four-cycle gasoline engines and to both two and four-cycle Diesel engines. It has been done commercially with piston pumps, positive-pressure rotating blowers and centrifugal blowers, and these applications have included blowers and pumps direct-connected to the main shaft of the engine, geared to the engine shaft and driven by belt,

Supercharger developments are presented by one of the discussers, who also advocates distributor-type injection systems and says that they can be developed to meet conditions as engine speeds are increased.

Ignition lag, rather than breathing capacity, is said to set the limit for engine speed, but the author maintains the truth of his statement that breathing capacity is the limiting consideration.

Greater flexibility is claimed for the double-chamber type of combustion-chamber by another discussor, who emphasizes the importance of turbulence and advocates limiting the injection pressure for the sake of durability of injection parts.

Contrasting the conditions for vaporization in an injection engine with conditions in an engine having a carbureter, the statement is made that the droplets of vapor contain something like 200,000,000 molecules. Finer atomization is said to be required for higher speed.

Supercharging is said to change the density of the gas enough to alter injection conditions. If this change is not taken into account, penetration of the jets may be insufficient to utilize the additional air provided by supercharging.

A brief account is given of experimental engines having common-rail fuel-feed varying in pressure according to the square of the engine speed. Nozzles are controlled either mechanically or electrically.

chain or electric motor. Some geared high-speed centrifugal blowers have been provided with an elastic connection to prevent breakage when the engine is slowed down more rapidly than the blower can be retarded. Centrifugal blowers for aeronautic, road, rail, marine and stationary engines also have been driven by exhaust-gas turbines. In fact, supercharging units as built by a number of prominent manufacturers have reached a stage where they should be considered seriously by all Diesel-engine builders for improving volumetric efficiency and assuring adequate scavenging.

Only incidental mention has been made of distributor systems in Mr. Ruehl's discussion of fuel-injection systems. Such systems, which are employed by several well-known manufacturers of engines for marine, stationary and automotive service, have the outstanding advantage that they assure an absolutely uniform distribution of fuel among the cylinders. The drip can be stopped and injection timing controlled just as accurately with the distributor systems as with other systems. Pumps are being operated in these systems up to a speed of 1800 injection strokes per minute.



OLIVER R. ALLEN

¹This paper was printed in the S.A.E. JOURNAL for February, 1931, beginning on p. 167. The author, who is a member of the Society, is assistant chief engineer, Diesel engine division, I. P. Morris & De La Vergne, Inc., Philadelphia. A brief abstract of the paper, as well as of the discussion, is printed herewith.

²M.S.A.E.—Consulting engineer, New York City.

No existing injection-pump would be suitable for a distributor system in a multiple-cylinder engine having a speed of 3000 r.p.m.; pumps must be developed for such speeds. However, as the speed of pumps has probably been tripled within the last five years, there is no reason why they cannot be developed to higher speeds as needed.

Simple injection-nozzles having a single opening have certain advantages as to reliability and low upkeep. More attention is being paid now, in the study of combustion, to the effects of turbulence. It is possible that improvements in combustion-chamber design, including provision for maximum turbulence, may result in lessening the necessity for small nozzle-openings without sacrifice in economy.

Data on Additional European Engines

Mr. Ruehl has given very complete data regarding the performance of a number of high-speed engines. A few additional examples from present practice are given in Table 1, herewith, the data for the first two, which are water-cooled aircraft engines, being taken from the Akroyd-Stuart Memorial Lecture given by D. R. Pye before the Royal Aeronautical Society, Dec. 11, 1930. The fuel consumption of the Packard air-cooled aircraft Diesel engine is given in this lecture as 0.35 to 0.40 lb. per b.hp., instead of 0.46 lb. as reported by Mr. Ruehl.

Also included in Table 1 are data on an Acro-system engine³ recently brought out by The Associated Equipment Co., Ltd., Southall, England, which is a little larger than the Saurer Acro-system engine mentioned by Mr. Ruehl, a McLaren-Benz high-speed engine and two additional two-cycle engines. The McLaren-Benz engine was developed for locomotive service, and full records of a test of one of them has been published⁴ which show exceptional uniformity in the performance of the six cylinders.

³ See *The Engineer* (London), March 7, 1930, p. 507.

⁴ See *The Engineer* (London), March 7, 1930, p. 265.

⁵ M.S.A.E.—Associate professor of engineering research, Pennsylvania State College, State College, Pa.

TABLE 1—DATA ON ADDITIONAL DIESEL ENGINES

	Beard- more	Junkers	A. E. C. Acro	McLaren- Benz	Modaag- Krupp	Peugeot- Junkers
Number of Cylinders	8	6 ^a	6	6	1 to 4 ^a	2 ^a
Bore	8 1/4	4 3/4	4 3/4	8 1/16	5 1/4	3 1/2
Stroke	12	8 1/4 x 2	5 1/2	10 1/2	10 1/2	5 1/2 x 2
Revolutions per Minute	1,000	1,500	3,000	1,000	500	1,000
Brake Horsepower	650	600	95	330	...	40
Total Cylinder Displacement, cu. in.	5,129	1,739	495	...	...	183
Engine Weight, lb.	4,500	1,648	1,350	...	...	...
Mean Effective Pressure, lb. per sq. in.	101	91	...	...	67	...
Piston Speed, ft. per min.	2,000	2,060	2,820	1,770	885	980
Weight/Displacement, lb. per cu. in.	0.605	0.95	2.72	...	...	...
Specific Weight, lb. per b.hp.	7	3.08	14	...	60-65	...
Specific Output, b.hp. per cu. ft.	330	600	332	...	...	...
Brake-horsepower per Cylinder	81	100	16	58	25	...
Fuel Consumption at Rated Mean Effective Pressure, lb. per b.hp.-hr.	0.35-0.40	0.375-0.40	...	0.44	0.38-0.40	0.42
Compression, ratio or lb. per sq. in.	12 1/4 : 1	14 : 1	15 1/2 : 1	650	550	...
Maximum Pressure, lb. per sq. in.	850	...	840	860	700-720	...

^a Double-piston two-cycle.

^b Two-cycle.

Neither of the two-cycle engines listed uses crank-case compression, the Modaag-Krupp having a positive-pressure scavenging pump direct-connected to the main shaft. Built in one, two and four-cylinder sizes, this engine has a rating for continuous output of 25 b.hp. per cylinder at 500 r.p.m., with a maximum rating of 5 to 10 per cent more. The Peugeot-Junkers is in regular production in France. The data in the table are from a motor-truck engine which has two pistons in each cylinder and a scavenging piston above each working piston.

E. F. RUEHL:—I appreciate Colonel Allen's interesting and hopeful remarks in regard to supercharging. I hope that standard superchargers will soon be available that are not handicapped by such high cost as are present superchargers.

Can Colonel Allen or anyone else tell of any improvements that have been made recently in the Packard engine to secure the fuel consumption of 0.35 to 0.40 lb. per b.hp.-hr., which he has reported, in place of that of 0.46 lb. which has been reported previously?

MR. ALLEN:—I understand that the data given by Dr. Pye were actual figures from the official test of the engine when it was approved, but I cannot say that positively. Presumably, the difference is that between what can be done under test conditions and what the manufacturer is willing to vouch for as its commercial performance.

Speed Limitations Imposed by Ignition Lag

P. H. SCHWEITZER⁵:—The engine described in this paper is designed on principles which coincide closely with

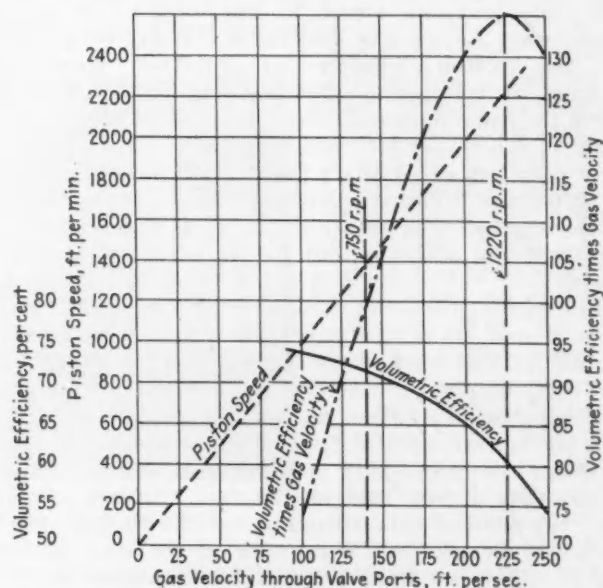


FIG. 1—VOLUMETRIC CURVES FOR DE LA VERGNE ENGINE

These Curves Are Based on the Assumption that the Gas Speed Is Six Times the Mean Piston-Speed, while the Author Says that the Gas Speed Actually Is Slightly Higher, in Relation to the Piston Speed. The Full-Line Curve Shows the Volumetric Efficiency in Relation to the Gas Velocity through the Valve Ports as Computed from Ricardo Tests. The Dash-Dot Curve Is Derived from the Product of the Volumetric Efficiency and Gas Velocity, with the Same Assumption as to Velocity. The Power Output Is Said To Vary Approximately as This Product and To Reach Its Maximum at 225-Ft.-Per-Sec. Gas-Velocity. The Dash Line Represents the Piston Speed

those which I advocate; therefore, I predict favorable test results and success with it.

The paper contains two statements with which I am unable to agree and should like to have Mr. Ruehl discuss in detail. The first is that "the real limit of power increase through an increase in speed is set by the natural breathing capacity, which depends on volumetric efficiency." The second is that "the ignition timing can be advanced to compensate for the ignition lag as the speed increases; therefore, the maximum engine-speed is not limited by ignition lag." I believe that these statements should be reversed, and will use the author's figures in trying to prove this.

The breathing capacity can be calculated. According to test results observed on different engines having poppet valves and normal valve-settings, as reported by Ricardo⁶, the volumetric efficiency drops with an increase in the rotative speed and air velocity as shown in the curve in Fig. 1. The power output is proportional to the product of the volumetric efficiency and the engine speed; therefore, the power should continue to increase with greater speed as long as the product of the volumetric efficiency and the speed in revolutions per minute increases. As the gas velocity is directly proportional to the piston velocity or rotative speed, the product of volumetric efficiency and gas velocity will serve the same purpose. This product reaches its maximum at 225 ft. per sec., which corresponds, on the basis of a mean gas speed of six times the mean piston speed, to 1220 r.p.m. This considerably exceeds the speed limit of the engine. The breathing capacity therefore should not limit the power output in the speed range of the engine.

Ignition lag, however, should limit the power output. Figs. 8 and 10 of the paper show that the injection period for full load is 18 deg. of crankshaft rotation and that the plunger velocity, and consequently the rate of discharge, is constant during this period. The ignition lag is estimated at 0.0018 sec., which corresponds to 8 deg. of crankshaft rotation at 750 r.p.m. That means that almost half of the fuel required for full load, an amount corresponding to 33.4 lb. per sq. in. m.e.p., is already in the cylinder at the time ignition begins. This accumulated fuel burns almost at once, as if thousands of spark-plugs had fired simultaneously. The result is a rapid pressure-rise which frequently manifests itself in roughness or knocking not unlike the detonation of a gasoline engine. The rate of pressure rise measured from Fig. 8 of the paper would be 395,000 lb. per sq. in. per sec., which is in the danger zone. I should like to know whether or not the author has had any difficulty with knocking.

Let us now suppose that the speed is increased to



DR. P. H. SCHWEITZER

1500 r.p.m. Then, virtually all of the fuel is injected before ignition occurs, so that destructive knocking will result, irrespective of the injection timing. This accumulation of combustible mixture resulting from the ignition lag cannot be prevented by earlier timing. Earlier timing is required at high speed, because most of the pressure rise must take place at or before top dead-center to prevent loss of power, high exhaust-temperature and smoke; but the earlier timing makes still worse the knock caused by the ignition lag, because the excessive pressure-rise comes while the piston is still going upward and the piston receives a violent backward push from the explosion.

Ignition lag must be reduced to a fraction of 0.001 sec. before really smoothly operating high-speed engines can be had; and the ignition lag, rather than the breathing ability, limits the maximum engine-speed.

Volumetric and Heat Limitations of Speed

Mr. RUEHL:—I am afraid that Dr. Schweitzer is too optimistic in regard to breathing capacity and too pessimistic in regard to time lag. Volumetric efficiency and heat conditions rather than time lag are what the practical man must battle with to increase the engine output by increasing speed without sacrificing much in combustion efficiency and torque.

Our 9 x 11-in. engine, which Dr. Schweitzer cites to make his point, has a theoretical air-velocity past the inlet-valve seats of about $6\frac{1}{2}$ times the piston velocity, ignoring friction and eddy losses and the influence of hot cylinder-walls. Dr. Schweitzer, in his computations, has assumed the air velocity to be six times the piston velocity. This air velocity of 150 ft. per sec. could be increased to 200 ft. per sec. by increasing the engine speed from 750 r.p.m. to the upper limit of 1000 r.p.m., at which speed just enough excess air might be drawn in to assure fair combustion at the present 75 lb. per sq. in. b.m.e.p. Beyond this speed, the brake mean effective pressure or torque, and consequently the rate of power increase through increase of speed, would drop considerably because of lack of combustion air and because of the large amount of heat to be disposed of.

This limitation exists in all commercial engines that are not supercharged and is referred to in Dr. Neumann's investigations of a 900-r.p.m. Dornier engine⁷. Time lag would not prevent running this engine at twice its rated speed without undue detonation. The time lag at 1500 r.p.m. would be 16 deg. of crankshaft rotation, and the fuel-pump timing would need to be advanced 8 deg. However, the cam contour for this extreme speed would be designed for an injection period of about 24 deg. instead of 18 deg., with more rapidly rising plunger velocity and therefore a more rapidly increasing rate of fuel supply than at 750 r.p.m., so that only about 60 per cent of the full plunger velocity would be reached during the 16-deg. time-lag period. That means that only $16 \div 24 \times 60$, or 40 per cent of the fuel required for full load, corresponding to 30 lb. per



E. F. RUEHL

⁶ See *The Internal-Combustion Engine*, by Harry R. Ricardo, Vol. 1, p. 131; Blackie & Sons, Ltd., London, 1923.

⁷ See *Zeitschrift des Vereins Deutsche Ingenieure*, May 28, 1927, p. 780 and Fig. 17, p. 784.

sq. in. b.m.e.p. would be in the cylinder at the moment when explosion begins. In addition, the time lag at 1500 r.p.m. would actually be much less than 0.0018 sec., because the combustion-chamber would be hotter than at 750 r.p.m. and this would considerably reduce the amount of fuel injected before burning begins.

The percentage of fuel injected during the 8-deg. time-lag at the rated speed of 750 r.p.m. is about $8 \div 18 \times 75$, or 33 per cent or less. This has resulted in no perceptible detonation, as is indicated by the very moderate explosion pressure, which rises gradually from a compression pressure of 420 lb. to only 640 lb. per sq. in. at full load and speed. The moderate degree of uncontrolled turbulence, resulting from the comparatively great piston-head clearance of 5/32 in., is largely responsible for this moderate pressure-rise. We do not wish to have very high pressure-rise nor very vigorous turbulence in phase 2, but we do desire directed air turbulence to secure smooth combustion and good fuel-economy.

Turbulence as an Aid to Distribution

J. E. WILD⁸:—One important difference between the various types of combustion-chamber seems not to have been sufficiently emphasized by Mr. Ruehl. It is fairly easy to design Diesel engines of the precombustion-chamber type or the Acro type which will run with clean exhaust at both low and high speeds, but it is difficult to secure clean exhaust at all speeds from single-chamber engines. This is because the maximum injection-pressure varies considerably with engine speed, affecting atomization and penetration of the spray and through them the combustion. The influence of decreased injection pressure at reduced speed is of secondary importance in the double-chamber engines because the mixing of air and fuel is accomplished by means which are much less influenced by the engine speed.

The influence of turbulence in single-chamber Diesel engines, which has been brought out clearly by Mr. Ruehl, often is underestimated. If sufficient turbulence is not provided for, the injection system must be depended upon entirely for the distribution of the fuel. More spray-nozzle holes of smaller diameter are required to distribute the fuel evenly in the combustion-chamber, and higher injection-pressures must be used to keep up the penetration with the smaller holes. The smaller holes are more easily clogged than larger ones, and increased pressure imposes stresses upon the fuel-pump and its drive which seriously affect the life of these parts. Thus combustion-chamber design which does not make sufficient provision for a high degree of turbulence imposes a penalty on the injection system.



J. E. WILD

The final solution must be such that a harmonious relation will exist between turbulence and injection pressure.

Injection pressures for small high-speed automotive Diesel engines of the single-chamber type should not need to exceed 4000 lb. per sq. in., and I believe that designs will be established in which good combustion is secured from sprays having maximum pressures of not over 3500 lb. per sq. in. An engine of this type will run smoothly, and its fuel consumption will be only slightly higher. For a given type of engine, the injection pressure must be determined from the performance of the engine over its entire load-range. If an engine produces equally clear exhaust when overloaded as when running at rated load, that is a sign that the injection pressure is unnecessarily high.

MR. RUEHL:—I agree with Mr. Wild's remarks as to the desirability of lower injection-pressure. We are all tending in that direction.

I had a long ride in a M.A.N. Diesel-engined truck, three years ago, during which the operator did not have to change the timing control between 400 and 1200 r.p.m. That engine had a smokeless exhaust at all speeds.

Time Lag Is Measured on Indicator Card

CHAIRMAN O. D. TREIBER⁹:—How was the time lag of ignition calculated by the author, and what other information about it is available?

MR. RUEHL:—The time lag was measured on the indicator cards, being approximately 8 deg. on the crankshaft in this case. It was also deduced from the pressure rise for the compression-pressure of 240 lb. to the explosion pressure of 640 lb. per sq. in. Some investigators have found that a pressure rise of 30 lb. per sq. in.

per deg of crank angle is the maximum that can be used without detonation. That corresponds with the pressures in our engine.

CHAIRMAN TREIBER:—Some years ago I made a similar study from which I arrived at an ignition time-lag of 0.0007 sec., but I am not sure that my figures were correct.

MR. RUEHL:—Increased heat shortens the time lag considerably during injection. At high torque and high speed, resulting in an exhaust temperature



W. F. JOACHIM

of say 900 to 1000 deg. fahr, the time lag may be only about one-half what it is at idling loads and low speeds. That is one of the conditions that makes it possible to omit timing control. Another reason why the control can be omitted is that there is a little more leakage past the fuel-pump plunger at low speed than at high speed, because of the increased time during which the leakage can occur.

J. OTTO SCHERER¹⁰:—It is apparent that Mr. Ruehl objects to the open nozzle because of dribbling. One European engine, which uses an open nozzle and a pump that is similar to the Bosch pump, has been run on test to prove that dribbling can be overcome with a correctly designed nozzle. In this test the engine was run for

⁸ M.S.A.E.—Vice-president, United American Bosch Corp., Springfield, Mass.

⁹ M.S.A.E.—Chief engineer, Diesel division, Hercules Motors Corp., Canton, Ohio.

¹⁰ M.S.A.E.—Consulting engineer, Detroit.

900 hr. at no load and 1000 r.p.m., and inspection showed the nozzle to be clean at the end of the test.

MR. RUEHL:—Are we to understand that this engine was running at a constant speed of 1000 r.p.m.? My point is that fouling is likely to occur from open nozzles at varying speed.

MR. SCHERER:—I do not know of many tests at low speed, but my own experience with this engine was that the nozzle was not appreciably carbonized after 10 to 20 hr. running at minimum idling speed with no load.

CHAIRMAN TREIBER:—Ricardo has pointed out that he has avoided difficulty at the nozzle because of the velocity of the air, which keeps it clean at the beginning and end of injection. Much the same thing occurs in the Hesselman engine and possibly in the De La Vergne.

L. F. BURGER¹¹:—The design of the pump, especially the way it starts and stops the injection, is much more significant than the question of open or closed-type nozzle.

A Study of the Spray

W. F. JOACHIM¹²:—Particles of fuel in the spray usually are between 0.0002 and 0.0004 in. in diameter. There are something like 200,000,000 molecules of oil in one of those particles. It takes a considerable time to vaporize these molecules from the little spheres of fuel and create a suitable admixture with the air in which they are to burn. The mixing process in the gasoline engine begins at the instant the fuel is picked up from the nozzle in the carbureter and continues as the fuel is carried through the inlet manifold and the inlet valve and during the suction and compression strokes. The mixture is then ignited by a spark which begins one of the most beautiful processes of flame propagation of which the internal-combustion engineer knows. Conditions in the Diesel engine are very different. Fuel is injected into the cylinder, at say from 10 to 40 deg. before top dead-center, in the form of a comparatively solid jet at the nozzle. This develops into a pear-shaped spray, the core of which is still essentially solid fuel, and beyond the outside fringe of the spray there is no fuel. Therefore we have all gradations of mixture in the spray from ultra-lean to ultra-rich, and a considerable difference in size of fuel particles as well.

¹¹ M.S.A.E.—Chief engineer, International Harvester Co., Chicago.

¹² M.S.A.E.—Senior mechanical engineer, division engineer, Westinghouse Electric & Mfg. Co., South Philadelphia, Pa.

¹³ Engineer, Walker Parccar, Oakland, Calif.

Consideration of the way in which the fuel sprays are distributed through the combustion-chamber discloses a still greater problem. It is possible to control the air in slow-speed engines, as pointed out by Mr. Ruehl, so as to make it rotate either circumferentially or like a smoke ring, and carry the more finely atomized particles from the edges of the spray to the combustion air which the spray has not yet reached. However, in an engine running at from 1200 to 3000 r.p.m., we must eventually have finer and finer atomization of the fuel to make the ratio of total fuel-surface to volume greater in order to secure rapid vaporization and more perfect combustion of the fuel.

Supercharging makes it desirable, if not necessary, to change the injection system to make sure that the spray penetrates the air in spite of its greater density. Otherwise, the net result may be that the spray penetration is reduced so that the fuel particles actually reach very little more air than they would in the same engine without supercharging.

Developing the Common-Rail System

BROOKS WALKER¹³:—We have a research and development laboratory in California in which we have been working upon Diesel engines for the last 1½ years in conjunction with H. E. Kennedy. The principal objection to the constant-pressure-line system for a variable-speed engine seems to be that the injection for a given throttle setting ordinarily extends over a constant crank-angle. When the engine is slowed down because of increased torque requirements, as when a hill is encountered, the engine receives a greater amount of fuel per cylinder charge at full throttle. We have developed a common-rail system in which the pressure in the line varies as the square of the engine speed, which gives accurate metering at variable speeds with a constant angular timing of the injection. We have also developed a constant-line injection for a common-rail pressure-system, both mechanically and electrically controlled.

We have operated a 2⅞ x 3¼-in. engine with this electrically-controlled system at idling speeds as low as 300 r.p.m. and attained a maximum speed of 4500 r.p.m. on test. The electrically controlled nozzles have been tested up to a frequency corresponding to that required in a four-cycle engine at 22,000 r.p.m.

We have also operated a full Diesel engine with a compression pressure of 186 lb. per sq. in. We hope to be able to tell you more later about these and a 100-hp. 5 x 7-in. four-cylinder engine with electrically controlled injection which is to run at 1500 r.p.m.



Classifying Transmission and Rear-Axle Lubricants

Discussion of C. M. Larson's Annual Meeting Paper¹

AN OUTLINE is given in the discussion of the reason for attempting to classify transmission and rear-axle lubricants, and reference is made to earlier work that showed the method to follow. Attention is directed to lubricants that in gearshift tests do not fall on the curve of results from other lubricants because of channeling, and a question is raised whether departures from the curve are due to experimental error, as asserted, or to failure of resistance to coincide with the viscosity at high lubricant temperature. The errors, however, are said to be due to inability to get enough pressure in the pressure-viscosity determinations on fluid grease containing a large quantity of soap to give true viscosity values.

Results of some shifting tests made on a variety of oils and semifluid greases showed that, regardless of the original viscosity, if the temperatures were such that the true viscosities of the oils were the same, the shifting effort was the same, the effort not

being influenced by small quantities of soap or by small quantities of wax which separated at temperatures below the channeling point of the lubricants.

A point is made that pressure-viscosity data afford a means of predicting leakage of a lubricant from housings.

Surface finish of the pins and bushings in the pin test, rubbing speed, clearance, projected area and other factors affecting the results are debated. With lead-soap lubricants, slow rubbing-speed at low temperature is usually more severe than higher speed and is likely to produce scuffing that will cause the welding together of the pin and the bushing.

Owing to the tendency of sulphur to crystallize out of sulphur-saturated oils in an abrasive form, a suggestion is made, in discussion submitted after the meeting, that such compounds be not approved until laboratory tests have shown what results can be expected from their long-continued use.

CHAIRMAN H. C. MOUGEY²:—For many years we in the automobile industry have been worried with our inability to recommend transmission and rear-axle lubricants to the public. In many of our instruction books warnings have been issued against the lubricants ordinarily known as fluid greases, which contain a small quantity of soap. This warning has been issued, not necessarily because of any demerit or lack of merit on the part of the lubricants, but because the automobile engineers have not known how to classify and discuss these lubricants, and for that reason the only way in which they could intelligently make recommendations was to exclude all of them, the good ones along with those that might or might not be unsatisfactory.

The S.A.E. Lubricants Committee has been working hard on the problem of getting a system of classification whereby the fluid greases as well as the oils can be recommended by the automobile engineers, and the work that has been done at the Sinclair Refining Co.'s laboratories has helped enormously in this work.

Correlating Laboratory Tests with Service Results

C. M. LARSON:—The way to attack this problem of classifying transmission lubricants, both oils and greases, was paved to some extent by former information on motor oils. About 1928 Wilkin, Oak and Barnard did some work on cranking speeds of motor oils in service test-work. Their work very nicely correlated viscosity with cranking speeds. Mr. Mougey also carried on some former work on the transmission-oil series and on a few of the gear greases which showed

that this method offered the way for classifying transmission lubricants for the S.A.E. HANDBOOK.

All of our work is for the purpose of correlating service work in an actual engine or transmission or other piece of machinery with some test apparatus that we can use for duplicating tests and indicating the results that will be obtained in actual service.

You will note that three lubricants in Fig. 17 of the paper are decidedly off the curve; that is, lubricants Nos. 1 and 6 are the two that are classified as products that channel. These lubricants channeled when the first shifting movement was made, so that when the next three determinations were made, no lubricant was flowing into the mesh and a semidry resistance effort resulted which was not the true resistance of the lubricant to shifting effort. In other words, none of the lubricant was moved and the resistance was much lower than it should have been, based on the viscosity. In demonstration work on the road, one could very easily show much less resistance to shifting with a lubricant that channels at the temperature of operation. With lubricant No. 5 it was not possible to get enough pressure to drive it down to its true viscosity curve. A separated oil would have followed right on the curve and not on the pressure viscosities that we were able to get through this range.

D. P. Barnard, of the Standard Oil Co. of Indiana, has run some work on three transmissions which shows that the present transmissions lower the maximum shifting point to an appreciable extent. Work that is now being done on free-wheeling shows that, on one type of free-wheeling device, when the lubricant reaches 60,000-sec. viscosity, it becomes too heavy for easy shifting and correct functioning of free-wheeling. The other type of free-wheeling device shows this same effect at a viscosity of 100,000 Saybolt sec. So it is

¹ The paper was published in the S.A.E. JOURNAL, March, 1931, p. 321. The author is supervising engineer of the Sinclair Refining Co., New York City, and a Member of the Society. A summary of the trend of the discussion is printed herewith.

² M.S.A.E.—Assistant technical director and chief chemist, General Motors Corp. Research Laboratories, Detroit.

necessary to consider present-day transmissions and modify this 1,500,000 sec., which is based on cars that were in production prior to 1930.

Questions Reasons for Variations from Curve

W. H. GRAVES*:—I have followed this work very closely with members of the S.A.E. Committee on Fuel and Lubricants and have had to fall in line with the suggested method because I could not show any evidence that gearshifting or clutch-spinning did not necessarily follow viscosity. But I think perhaps it may be true that they do not exactly do that.

Mr. Larson indicated on the chart in Fig. 17 that 1,500,000 sec. was about the maximum viscosity at which to shift gears.

He stated that the reason the lubricants other than Nos. 1, 5 and 6 do not fall on the line is probably because of experimental errors. It seems peculiar that in every case the experimental error is either above or below the line he has plotted. For instance, in all cases lubricant No. 10 is above the line; No. 8 is below; No. 5, as he said, is an exception; No. 3 is on the line; Nos. 7, 11 and 12 are below; and No. 2 is appreciably above the line.

If we compare oil No. 11, which has a viscosity of 1,500,000 sec., which Mr. Larson says is the highest at which the shift can be made, with oil No. 8, having a viscosity of less than 300,000 sec. at 100 deg. fahr., we see that the difference in shifting effort is very little. The same is true with Nos. 10 and 12.

If No. 2 oil were taken out, the curves would be nearly flat and would not show that shifting effort increased proportionally with increased viscosity. If those are experimental errors, it is peculiar that in each case they should always be in the same direction. While I have no data to show that those positions are not true, some of our work has indicated that they might not be. Also, when stopping clutch-spinning with the grease, we believe that they do not follow the viscosity curve.

Pressure Viscosity Is Not True Viscosity of Soap Greases

CHAIRMAN MOUGEY:—Mr. Larson, these are pressure viscosities, are they not?

MR. LARSON:—Yes; the error is due more to the pressure viscosity than to the actual-resistance determinations.

CHAIRMAN MOUGEY:—The viscosity of the separated oil is given in Table 1 of the paper. The Committee found that, while pressure viscosity was a means of determining the viscosity of both oils and fluid greases, if they did not have too much soap in them, the values on the chart for No. 8, for example, are too high. If the fluid grease contained a large quantity of soap, we could not get enough pressure to give true viscosity values.

You will note that the viscosity of the separated mineral oils is lower, and that throws them more nearly

on the curve. The chart was developed to show that, in classifying lubricants, it is necessary to use the viscosity of the separated mineral oil rather than the pressure viscosity of the lubricants, because in some cases, as in those shown, we cannot obtain the true viscosity by means of pressure viscosity. We either cannot get enough pressure to force the viscosity down on the line or we get too high a pressure; again, we get a reading that is too high.

ABBOT A. LANE†:—Is it not true that the pressure viscosity is an absolute viscosity? In other words, two lubricants of the same absolute viscosity but one having one-half the density of the other would show the same viscosity on pressure determination but would not show the same viscosity on Saybolt determination.

Found Shifting Resistance Coincides with Viscosity

ROBERT E. WILKIN‡:—The viscosities that we are considering here are the viscosities of mineral oils. The gravity of the oils is practically the same. However, if we were to consider the viscosities of fluids having widely varying specific gravities, we should have to consider the absolute viscosities.

Mr. Larson referred to some of our experience. We did some of the original work on pressure viscosity which was intended to show the effect of oil viscosity on engine starting-torque. To determine what property of lubricants affects shifting effort, a number of tests were run on a variety of oils and semifluid greases in which the viscosity of the oils varied considerably. The temperatures at which the tests were made were not all the same, and variations in viscosity were obtained by using different lubricants. We used three different transmissions: the synchromesh, the internal-gear type used in the

four-speed transmission, and the conventional three-speed transmission.

The results of this work showed that, if we plotted the shifting effort against the viscosity of the oil at the temperature of the shift, the results in each case would plot as a straight line. That is, regardless of the original viscosity of the oil, if the temperatures were such that the viscosities at each test were the same, the shifting effort would be the same. The effect of soap in semifluid lubricants or of the lubricants at temperatures below their cold test did not influence the shifting effort; the factor that affected it was the viscosity of the oil present in such lubricants at the temperature at which the shift is made.

Pressure Viscosity as a Leakage Indicator

J. R. MACGREGOR§:—The subject of classifying lubricants is of much interest for several reasons. One of them is that somewhat of a revolution is occurring in the types of power transmissions used, both in transmissions proper and in rear axles. Also, we have partly worn-out vehicles in which suitable lubricants must be used.

This brings us to another use for the pressure-viscosimeter data. By using the data in a somewhat different way, plotting pressure against the flow rate, we find that a certain pressure is required for greases or so-called solidified oils to cause any flow whatever. This initial flow, or yield-point, is indicative of a ten-



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dency of the product to travel along the inside of the housing or along the shaft, resulting in leakage at the rear wheels or, in the case of loose rivets, at such points. The pressure-viscosimeter data, used in this way, give us a good means of predicting just what the lubricants will do as regards leakage. That, I think, is not possible by any consideration of viscosity.

I should like to have more information on the number of tests that were made on any one lubricant in the pin test to assure accuracy of the determination and also on what arrangements were made for taking account of the difference in the surface of the pins even though they were machined as carefully as possible. We have done considerable work with journals and found that the actual condition of the journal has much to do with the results obtained, frequently having more influence than the lubricant itself until the shafts are thoroughly worn in and all surfaces are alike.

Surface Finish and Rubbing Speed in Pin Test

CHAIRMAN MOUGEY:—Our laboratory has done an enormous amount of work on checking these different lubricants with this pin-test machine and finds that the ordinary commercial limits of machining are entirely satisfactory, enabling us to obtain results that check with remarkable accuracy. From one to six tests can be run with the same oil, using different pins and bushings in all the tests, and the curves will lie one right on top of another.

MR. LANE:—Have any tests been run to determine whether varying the clearance from 0.007 in. to less would be beneficial for the lighter lubricants?

J. O. ALMEN⁷:—In developing this machinery at the General Motors research laboratory, we covered the ground of the material, finishes and clearances, and found that the clearances were not very critical. They could vary within wide limits and still give very satisfactory results. We also found that, although the load-supporting area as shown by the worn marks in the bushings may vary considerably between the small clearance and large clearance, it affects results very little in this pin test.

E. WOOLER⁸:—One very important item that does not seem to have been mentioned in the paper is the rubbing speed. What is the rubbing speed on the machine used in making these tests? On the Timken testing machine we ran 300 or 400 ft. per min., which we understand is the usual rubbing speed of the rear-axle-gear teeth, although we think that they may run as high as 900 ft. per min. in some instances. Your machine seems to run much slower than that.

CHAIRMAN MOUGEY:—This machine has a 1-in. pin and runs at 100 r.p.m. in this particular test described by Mr. Larson. With lead-soap lubricants in general, the test is made more severe, believe it or not, by running it at 25 r.p.m.; lead-soap lubricants that will pass at 100 r.p.m. in some cases will fail badly at 25 r.p.m.

MR. WOOLER:—Even 100 r.p.m. is only about 25 ft. per min., which is very low. We found that the rubbing speed is a big variable affecting film strength.

CHAIRMAN MOUGEY:—What we have tried to do has been to obtain lubricants on the market, determine their performance in service and check their performance on the machine. With lead-soap lubricants, we find that a speed of 25 r.p.m. is much more severe than 100 r.p.m. We have not been able to find a lubricant that is approved by the Gleason Works which will not pass the 25-r.p.m. test. We have found some that would pass the 100-r.p.m. test but would fail in the 25-r.p.m. test, and those lubricants were not passed by Gleason.

Factors That Affect Lubricant Temperature

ELTON S. STEPHENS⁹:—The Consistometer Corp., of Chicago, has worked for the last five years on testing lubricating qualities, particularly on developing tests for oiliness of lubricants. We find that finish of surface, pressure on projected area, speed and the rounding of corners where the lubricant enters all affect oiliness determinations. If we take two samples of oil out of the same sealed can and run two tests with identical pressure on projected area, identical finish of surface and identical speed, but change the leading edges of the grooves admitting the oil into the clearance between the discs on our instrument from sharp to rounded, we observe a temperature difference in relative transition point of the oil of sometimes as much as 40 deg. fahr.

MR. ALMEN:—Probably some misunderstanding exists as to the pin test. This is not film lubrication in the ordinary sense, where there is separation of the metal surfaces by the lubricant, and I think that is where the misunderstanding comes in. The separation of the surfaces is effected by some other material than the lubricant that is used, the lubricant serving only as a carrier for whatever the material is that separates the surfaces and prevents them from seizing.

E. G. BODEN¹⁰:—Why is it that when you decrease the rubbing speed to 25 r.p.m. you have seizure?

CHAIRMAN MOUGEY:—We believe the reason is that the higher temperature developed at the higher speed causes chemical action between the lubricant and the pin, and that, in the case of lead-soap lubricants, this chemical action is not caused at the lower temperatures.

MR. BODEN:—If that is the case, the test is rather unfair, because the viscosity changes when the temperature becomes high.

CHAIRMAN MOUGEY:—Our object has been to develop a test that would duplicate in the laboratory the performance of lubricants in service on hypoid gears.

MR. LARSON:—We have found in connection with slow rubbing-speeds that, when a 5-hp. motor is used, the seizure is more complete and the pins are ruptured more than if a 25-hp. motor is used. In our first test, to economize on our set-up, we used a low-horsepower motor and found that when the motor slowed down to about 25 r.p.m. the pin was so completely welded to the bushings that a pressure as high as 43 tons was

(Concluded on p. 576)



H. C. MOUGEY

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⁸ M.S.A.E.—Chief engineer, Timken Roller Bearing Co., Canton, Ohio.

⁹ M.S.A.E.—Vice-president, chief engineer, Consistometer Corp., Chicago.

¹⁰ M.S.A.E.—Experimental engineer, Timken Roller Bearing Co., Canton, Ohio.

A Survey of Current Automobile and Bus Fuel-Line Temperatures

Discussion of Annual Meeting Paper¹ by Oscar C. Bridgeman² and Hobart S. White³

PREVIOUS work on vapor lock at the Bureau of Standards under the auspices of the Cooperative Fuel Research Steering Committee has resulted in considerable information regarding the relation between the properties of gasolines and vapor lock and between fuel-line design and vapor lock. Satisfactory means have been developed for predicting the conditions under which vapor lock would occur with a given fuel, but no extensive information has been available on the gasoline temperatures existing in the fuel feed lines of automotive equipment. This has made it very difficult for the refiner to supply fuels that are satisfactory for current automotive equipment.

The present report includes temperature data obtained at several points in the fuel-feed systems of 27 automobiles and 8 buses under various operating conditions. At 40 m.p.h., the maximum temperature observed in the fuel systems of the passenger-cars studied was 73 deg. fahr. above atmospheric temperature, while the average temperature at the fuel-pump or vacuum-tank outlet for the 27 cars was 41 deg. above that of the atmosphere. During idling after a 40-m.p.h. run, the temperature increased still further by as much as 20 deg. The fuel-line temperatures found in the buses investigated were, on the average, slightly lower than those found in the passenger-cars.

CHAIRMAN JOHN B. MACAULEY⁴:—Replacing the vacuum tank with the engine-driven fuel-pump has been, I believe, a good move. I think few designers would care to go back to the vacuum tank, but the change has undoubtedly introduced two complications in regard to vapor lock. First, the fuel-pump has virtually no vapor-handling capacity. If its liquid capacity is little more than enough to supply the engine at high speed and part of the fuel is vaporized, the delivery will be insufficient. Second, the pump causes considerable rise in temperature in the gasoline, because it usually is mounted on the hot crankcase, driven from the camshaft and shielded from the air-stream.

Refiners stand ready to supply more volatile fuels than in the past if they can be used. Failure to make possible the use of such fuels causes a loss to the refiners and to everyone involved. A large quantity of petroleum products must be thrown away or diverted to less profitable use. This condition puts it up to the

The results obtained reflect seriously on the design of automobile fuel-feed systems, and certain suggestions are made regarding improvement in design on the basis of the experimental data. It is considered that the introduction of fuel-pumps has been more responsible for the widespread occurrence of vapor lock than has any increase in the average volatility of fuels during the last two years, and therefore it behooves the automotive engineer to do his part in keeping the fuel system as cool as possible. With some care and thought on the part of the designer, it is felt that the gasoline temperature at the fuel-pump can be materially reduced.

Tests conducted in the laboratories of an oil company and a university to determine the fuel-line temperatures in cars are reported in the discussion, one group being plotted together with data from the paper. Formulas are given for estimating the maximum fuel-temperature in the car and the temperature at which vapor-locking will occur in a fuel, also a scale for determining the vapor-locking temperature from the Reid vapor-pressure.

Reference is made to the economic loss from the waste or diversion of the more volatile fractions of the fuel, which also are desirable for easy starting. One discussor reports a notable difference in fuel economy caused by change in temperature of the carburetor float-chamber.

engine designer to furnish a fuel system that can handle fuels of high volatility.

The temperature of the air passing through the radiator and the temperature of the crankcase impose definite limitations. According to the relation between vapor-locking temperature and the A.S.T.M. 10-per-cent point, established in the paper which Dr. Bridgeman and Miss Aldrich gave last year on the Properties of Gasoline with Reference to Vapor Lock⁵, the car showing the maximum temperature at 40 m.p.h. would vapor lock at an atmospheric temperature of 72 deg. fahr. on a fuel having a 10-per-cent point of 145 deg. fahr.

Vapor locking at idling temperature is important not only because it interferes with idling but because the fuel supply will fail in driving hard after idling.

Tests Made by a Refiner

F. C. BURK⁶:—Since refiners had insufficient data regarding temperatures in the fuel systems of automotive equipment, it was necessary for us to actually measure such temperatures from a group of representative cars having various fuel-system designs. Gravity, fuel-pump and vacuum-tank systems were investigated by inserting calibrated thermocouples at critical points, used in conjunction with an especially constructed direct-reading millivoltmeter. Fuels were prepared for

¹ Published in the S.A.E. JOURNAL for March, 1931, beginning on p. 315. The original abstract of the paper is reprinted herewith, together with a brief abstract of the discussion.

² S.M.S.A.E.—Research associate, Bureau of Standards, City of Washington.

³ Junior physicist, Bureau of Standards, City of Washington.

⁴ M.S.A.E.—Experimental engineer, Chrysler Corp., Detroit.

⁵ See S.A.E. JOURNAL, July, 1930, p. 93.

⁶ Jun. S.A.E.—Junior automotive engineer, Vacuum Oil Co., Paulsboro, N. J.

the tests by blending casing-head gasoline with a fuel that would not vapor lock, varying the percentages until a vapor-locking temperature approximately 40 deg. fahr. above atmospheric temperature was obtained.

The entire fuel system of the car was drained before the prepared fuel was supplied. The car was driven on the road at 40 m.p.h., as maximum fuel-system temperatures were observed at this speed. If vapor locking occurred, the car was immediately stopped and a sample of the fuel was withdrawn from the fuel system. This sample was returned to the laboratory for a Reid vapor-pressure determination. If vapor locking did not occur after a run of approximately 20 to 30 miles, additional casing-head gasoline was added to the rear tank. This procedure was repeated until locking occurred. After vapor locking, gasoline of the lower vapor-pressure was added to the rear tank until vapor locking would no longer occur. Reid vapor-pressures at 100 deg. fahr. were obtained from all samples removed at the point of vapor lock. Care was taken to secure samples that represented the fuel which was actually locking, as weathering in the vacuum tank will lower the vapor pressure of the fuel throughout the system.

Formula Predicts Vapor-Lock Temperature

From the data obtained, it was determined that vapor lock occurred at the outlet of the vacuum tank in fuel-feed systems containing this unit, and generally at the pump inlet in fuel-pump systems. The data secured were compared with predicted vapor-locking temperatures which were computed by the substitution of the Reid vapor-pressure in relations previously found by the Bureau of Standards. The equation⁷ for predicting vapor-lock temperature from the Reid vapor-pressure is, in reduced form:

$$t = 259 - 140 \log p_r \quad (1)$$

where p_r is the Reid vapor-pressure at 100 deg. fahr., in pounds per square inch, and t is the vapor-locking temperature, in degrees fahrenheit.

The vapor-locking temperature as calculated from

⁷ See S.A.E. JOURNAL, July, 1930, p. 95, equation (1).

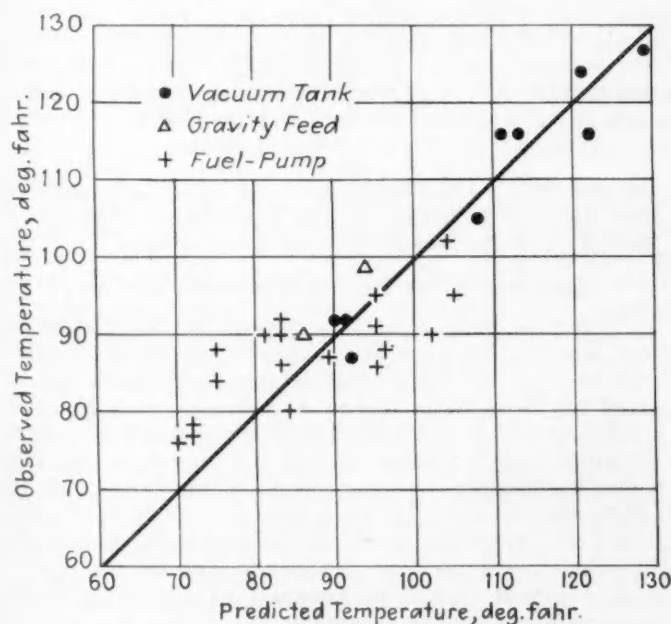


FIG. 1—DEVIATION OF OBSERVED FROM PREDICTED TEMPERATURES

TABLE 1—VAPOR-LOCK OBSERVATIONS FROM VACUUM OIL CO. ALL TEMPERATURES IN DEGREES FAHRENHEIT

Car No.	Atmospheric Temperature	Fuel Temperature at Time of Lock			Reid Vapor-Pressure at 100 Deg., Lb. per Sq. In.		
		Inlet Temperature ^a , Observed	Outlet Temperature ^a ,		At Main Tank	At Vacuum-Tank Outlet	
			Observed	Predicted			
							<i>Vacuum-Tank Feeds</i>
1	{	72	...	116	111	12.0	11.5
		72	...	116	122	10.0	9.4
		68	...	124	121	9.9	9.6
2	{	70	...	105	108	14.2	12.1
		70	...	116	113	...	11.0
3	{	79	...	127	129	10.8	8.5
		50	...	87	92	17.3	15.7
		50	...	92	91	...	15.9
		50	...	92	90	...	16.1
<i>Gravity Feed</i>							
4	{	72	...	90	86	17.2	
		74	...	99	94	15.2	
<i>Pressure Feeds</i>							
5	{	71	88	96	96	14.4	
		71	91	100	95	14.8	
6	{	75	95	106	105	12.6	
		75	86	94	95	14.9	
		75	90	98	102	13.2	
		62	76	80	70	22.5	
7	{	49	77	86	72	21.6	
		49	78	85	72	21.6	
		52	88	100	96	14.6	
		52	102	...	104	12.7	
		51	80	90	84	17.8	
8	{	51	87	105	89	16.3	
		60	90	...	81	18.8	
		60	84	88	75	20.5	
		61	88	95	75	20.7	
9	{	61	90	96	83	17.9	
		58	86	103	83	18.0	
		67	92	102	83	17.9	
		59	95	110	95	14.9	

^a Data taken at the sediment bowl of gravity-feed cars and at the vacuum tank or fuel-pump of cars equipped with these units.

this equation agrees very closely with the temperatures observed in the vacuum-tank cars and is 4 to 5 deg. fahr. low for the gravity system. Agreement for the fuel-pump cars is slightly variable, but the average pump-inlet temperature only approximates the predicted temperature.

Table 1 and Fig. 1 show the predicted and observed vapor-lock temperatures in connection with these tests, which were made in the fall. As the atmospheric temperatures were considerably lower than they would be in the summer, it was necessary to use fuels having vapor pressures higher than those of commercial fuel. Since the formula for vapor-locking temperature holds reasonably true at these high vapor-pressures, there is every reason to believe that the observed and predicted temperatures will maintain their relationship at the lower pressures; in fact, the agreement may be closer, although tests have not been made to establish this point.

The duplex scale shown in Fig. 2 is based on values found by substituting assumed values of the Reid vapor-pressures in equation (1). The vapor-locking temperature of a gasoline can be read on this scale if the Reid vapor-pressure is determined. The highest vapor-locking temperature observed in our tests was 48 deg. fahr. above atmospheric temperature. Assuming a maximum summer temperature of 105 deg. fahr., the Reid vapor-pressure could not be higher than 5.7 lb. per sq. in. if vapor lock is to be avoided while maintaining a speed of 40 m.p.h. The average observed vapor-locking temperature was 33 deg. fahr. above atmospheric; and a Reid vapor-pressure of 7.3 lb. per sq. in. would be required to prevent vapor locking while running at 40 m.p.h. Fuel having a Reid vapor-pressure no higher than 6.5 lb. per sq. in. must be marketed by the refiner

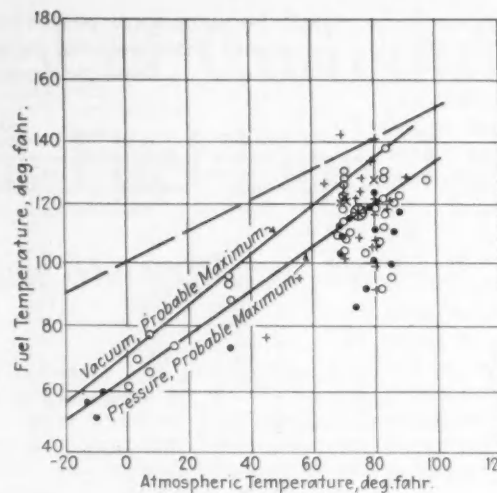
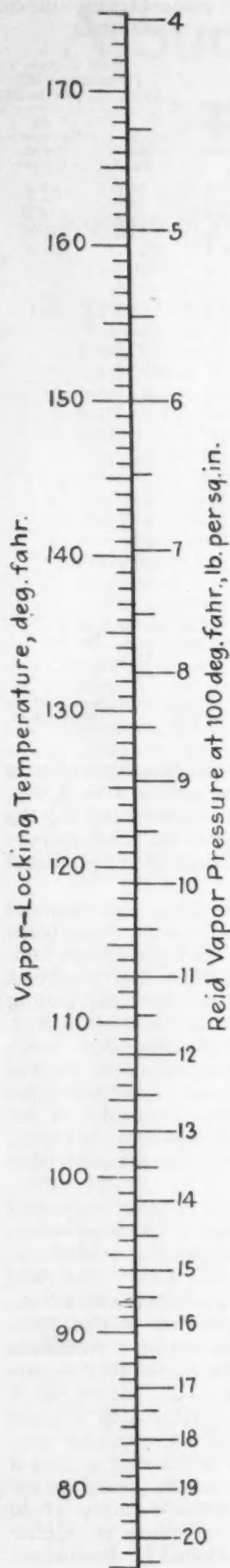


FIG. 3

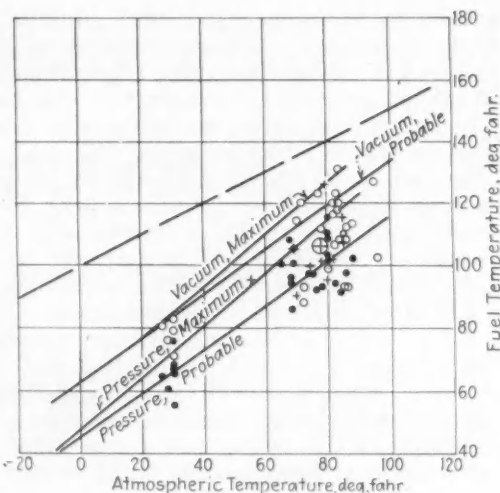


FIG. 4

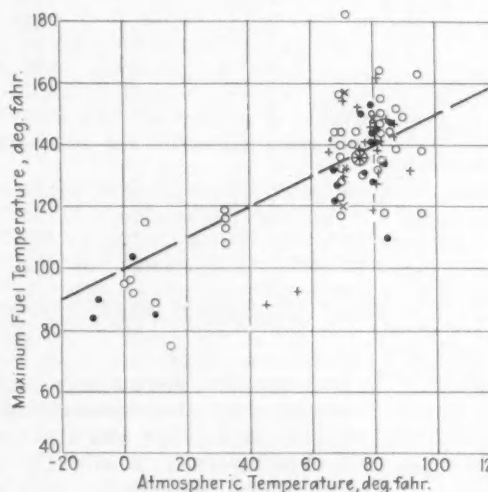


FIG. 5

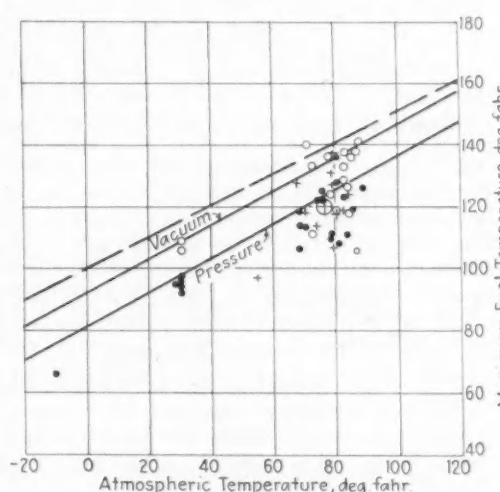


FIG. 6

MAXIMUM FUEL TEMPERATURES PLOTTED AS A FUNCTION OF THE ATMOSPHERIC TEMPERATURE
Data from Michigan University Tests Are Indicated by Circles for Vacuum-Tank Feeds and Dots for Pressure Feeds. Data from Tests Reported in Table 2 of the Paper Are Indicated by \times for Vacuum-Tank Feeds and $+$ for Pressure Feeds

FIG. 3—FUEL-LINE TEMPERATURES AT 40 M.P.H. OR LESS AND IDLING

FIG. 4—FUEL-LINE TEMPERATURES AT SPEEDS OVER 40 M.P.H.

FIG. 5—CARBURETER-BOWL TEMPERATURES AT 40 M.P.H. OR LESS AND IDLING

FIG. 6—CARBURETER-BOWL TEMPERATURES AT SPEEDS OVER 40 M.P.H.

to prevent vapor lock in the summer in the majority of cars.

More extensive use of efficient stabilizing equipment is therefore indicated for the oil companies, in order to remove excessive propane and thus lower the vapor pressure of

the gasoline. The later models of some cars indicate that automobile engineers are striving to lower fuel-system temperatures to prevent vapor lock.

Expression for Fuel Temperature in Car

GEORGE G. BROWN*:—Data concerning the maximum fuel temperature in a large number of motor-vehicles such as have been presented by Dr. Bridgeman are of great practical value to the oil industry in indicating conditions under which fuel must give satisfactory performance and to the automotive industry in indicating where automotive equipment may be improved so as to handle the more volatile fuels in a satisfactory manner. It is hoped that this work will be continued to include investigation of the new designs of automotive equipment and that it will be extended to include tests at lower atmospheric temperatures.

In the course of work done for the Natural Gasoline Association of America², an extensive series of tests

* M.S.A.E.—Professor of chemical engineering, University of Michigan, Ann Arbor, Mich.

² See Engineering Research Bulletin No. 14, University of Michigan, Department of Engineering Research, May, 1930.

FIG. 2—SCALE FOR DETERMINING VAPOR-LOCKING TEMPERATURE FROM REID VAPOR-PRESSURE

under different driving conditions on a limited number of motor-vehicles gave results very similar to those reported by Dr. Bridgeman. It was found that the maximum fuel temperature in degrees fahrenheit under most driving conditions would not exceed that represented by the following equation:

$$\text{Maximum fuel temperature} = 100 + 1/2 \text{ atmospheric temperature} \quad (2)$$

This approximation of the maximum fuel temperature is perhaps more satisfactory than simply estimating the difference between the fuel temperature and the atmospheric temperature, because with modern cars equipped with thermostatically controlled radiator shutters the temperatures under the hood tend to remain more nearly constant than does the atmospheric temperature, and the difference between the maximum gasoline temperature and the atmospheric temperature may be considerably greater in cold weather when the shutters are closed than in warm weather when the shutters are completely open.

For comparison, I have plotted a number of the temperatures recorded in Table 2 of the paper under discussion upon the same charts used in plotting the data we secured in the earlier tests. Fig. 3 is a reproduction of our Fig. 103, with the addition of temperatures under idling conditions for the fuel-pump or vacuum-tank inlet from Table 2. Idling conditions were chosen because these temperatures are considerably higher than when driving at a constant speed and represent nearly the same conditions as those under which our data were secured. Our Fig. 103 was originally marked to indicate speeds of 40 m.p.h. and less, and represents data obtained under idling conditions and when the speed of the car was suddenly reduced from high speed to low speed as when entering city traffic. The agreement between the two sets of data is as good as could be expected; the average from Table 2, indicated by a cross inside a circle, falls exactly on the line indicating maximum probable temperature.

Maximum temperatures at speeds higher than 40 m.p.h. from Table 2 have been plotted in the same manner on our Fig. 104, which is given herewith as Fig. 4. The cars having vacuum feed seem not to have been driven faster than 40 m.p.h. in the tests reported by Dr. Bridgeman. The agreement between the two sets of data is excellent, and the average from Table 2 falls between the two lines on the chart indicating the maximum and probable temperatures under pressure-feed conditions.

Our Figs. 105 and 106 are reproduced with the additional data in Figs. 5 and 6. Again the agreement is excellent, and the average maximum temperatures from Table 2 fall almost exactly on the lines representing the averages of our tests. Our work also included measurement of the temperatures in the carbureter jets. These were found to vary within the same limits as those of the carbureter bowl.

Under steady-driving conditions, the maximum fuel temperature exceeded that indicated by equation (2) in only two isolated cases. Under idling conditions after fast driving, the temperature indicated by equation (2) and the dash line in Figs. 3 to 6 may be taken to represent the average of maximum fuel temperatures. This means that any fuel that does not cause vapor lock at the temperature indicated by equation (2)

will operate satisfactorily in all cars under steady-driving conditions and in approximately one-half of the cars under the most severe conditions such as idling after hard driving. To put it another way, equation (2) indicates the maximum fuel temperature for 50 per cent of the cars under all conditions and for all of the cars under conditions encountered during 80 to 90 per cent of the driving time.

Dr. Bridgeman has suggested a number of means by which a maximum fuel temperature of cars now causing excessively high temperatures can be decreased. It is particularly important that the design of such cars be improved so that they will operate satisfactorily with the more volatile fuels. The easier starting and relative freedom from use of the choke with the more volatile fuels causes the public to demand and the service-station to supply the more volatile fuel, which may cause difficulty from vapor lock in those cars which are not designed to limit the maximum temperature of the liquid fuel.

I believe that the maximum fuel temperature in degrees fahrenheit, even under idling conditions in cars equipped with radiator shutters, should not exceed that indicated by the following equation:

$$\text{Maximum fuel temperature} = 80 + 1/2 \text{ atmospheric temperature} \quad (3)$$

This allows for a rise of 40 deg. when the outside temperature is 80 deg. and a rise of 30 deg. if the outside temperature is 100 deg.

Vapor-Lock Experience from Texas

G. G. OBERFELL¹⁰:—Our experience in marketing gasoline in the summer in Texas, which probably represents the hottest weather conditions encountered in this Country, is that no vapor-lock difficulties are encountered with a product which has a Reid vapor-pressure limit of 8 lb. per sq. in. when it leaves the refinery.

I should like to correct an apparent misunderstanding to the effect that vapor-locking difficulties of recent years are due to increased usage of natural gasoline. The amount of natural gasoline used during the last 8 to 10 years has increased only 1 to 2 per cent in relation to the total amount of motor fuel. The Reid vapor-pressures of natural gasolines vary from 15 to 30 lb. per sq. in.; consequently, the increased vapor-pressure of motor fuel because of this increase in the use of natural gasoline would be about 0.3 lb. Therefore, some other source must be found for the recent difficulties with vapor lock. The cause is to be found in such things as vapor-recovery systems and the widespread practice of cracking.

OSCAR C. BRIDGEMAN:—Mr. Oberfell's remarks bring to mind a point that I failed to state; namely, that vapor-lock values quoted in the paper are vapor-pressures of the fuel in the fuel-feed system, not vapor pressures determined at the refinery or at the filling station. I think it can be assumed that the pressure of 8-lb. gasoline will be reduced 1 lb. between the time it leaves the factory and when it is used and that the pressure of 6-lb. gasoline will decrease about 1/2 lb.

J. O. EISINGER¹¹:—Fuel economy is not causing much concern at present, but we have made road tests in which the carbureter float-bowl was kept at the point of incipient vapor-lock, which was 140 to 150 deg. fahr. The car performed satisfactorily with a fuel consumption of about 12 miles per gal. Reducing the float-bowl temperature to 120 to 125 deg., the mileage was increased to about 16 miles per gal.

¹⁰ Phillips Petroleum Co., Detroit.

¹¹ M.S.A.E.—Research engineer, Standard Oil Co. of Indiana, Whiting, Ind.

DR. BROWN:—Might not this increase in mileage be due to a change in mixture ratio because of changed viscosity and density of the fuel?

MR. EISINGER:—Such a relatively small change in temperature would not, I believe, cause an appreciable

change in viscosity or density, so that the mixture ratio would be virtually unchanged.

CHAIRMAN MACAULEY:—I have seen evidence of severe weathering losses in the vacuum tank; probably the same thing occurs in the carburetor bowl.

Classifying Transmission and Rear-Axle Lubricants

(Concluded from p. 571)

required to push some of the bushings out of the carriage. That seems to check very thoroughly with what Mr. Mougey said; the scuffing at slow speed and low temperatures is much more complete and the likelihood of welding the two surfaces together is greater.

MR. MACGREGOR:—In that pin-test machine, do you have, besides the 0.007-in. clearance, any other means for allowing entry of oil than at the end of the bearing?

CHAIRMAN MOUGEY:—Yes, the bearings are all drilled with an oil-hole in the center on the slack side.

Sulphur-Saturated Oils Unstable

C. B. KARNS¹¹:—Apart altogether from questions of ability to lubricate or to withstand unusual pressures and the sliding friction encountered, which distinguish lubricants of these types from ordinary petroleum oils or greases, we must look farther as to the effects from long-continued use. Continued use of a properly manufactured leaded oil should result only in a continued improvement of the lubricant because, with the changes of temperature encountered, the lubricant will have a tendency to absorb a small quantity of moisture due to sweating, and the lead oleate will become slightly hydrated, thereby forming a nonseparable mixture and one having greater lubricating properties than when first introduced. This has been proved by years of experimenting and actual testing and is one of the secrets of the continued success of leaded oil.

In comparison, the sulphur-saturated oils, which at the start may be thought to be working successfully, form sulphides of the metal and wear down to a final

smoothness. Just what may we expect from their continued use under exacting service? There is always a deep mystery about what a sulphur-saturated oil may do even overnight. Its stock of energy for change is inexhaustible, and, while we may base our results on what we think we have, we may discover that we are mistaken. The manufacturers of sulphur cutting-oils

will agree with me that to hold sulphur in solution is a difficult task. Even though the product may be perfected to supposedly clear solution, when we clean out our tanks or the tank cars used for shipping, we find a sediment of sulphur which shovels out like gritty sand and is not a substance that one would care to recommend for the lubrication of high-grade automobile gears. A clear solution of sulphur in oil, upon standing overnight or for days or weeks, may go bad and the sulphur may crystallize out in an abrasive form. A sudden chilling down to zero often starts the formation of these sulphur crystals. Therefore we should be reasonably sure what the effects of after years will show from sulphur oils before

placing our stamp of approval on them as a result of laboratory tests.

The introducing of sulphur into transmission oils has, to my mind, not as yet been determined as desirable, whereas years of study and service have proved that lead, properly compounded as a soluble soap free from solid sediment and abrasive material, is highly desirable not only for hypoid gears but for all classes and types of gear, because of the superior film held by the lead under high pressure, thereby allowing the use of an oil that is more limpid or fluid than a straight mineral oil for the service encountered in the operation of gears.



C. M. LARSON

¹¹ Manager, manufacturing plants, Standard Oil Co. of Pennsylvania, Pittsburgh.

Review of Riding-Qualities Research

Much progress has been made in the last decade in measuring the many factors of motor-car vibration that cause the passenger discomfort and fatigue. Reports of portions of this work have appeared from time to time in various publications. It is believed that a summary of the work that has been done will assist the practical engineer in the more extensive application of the results of the researches.

Such a summary was presented by Roy W. Brown, of the Firestone Tire & Rubber Co., at a recent meeting of the Indiana Section and is printed herewith, followed by a portion of a progress report by Dr. F. A. Moss, of George Washington University, and part of a report by Prof. Ammon Swope and Prof. G. C. Brandenburg, of Purdue University, on instruments for measuring bodily fatigue, which were presented at the Annual Meeting of the Society in January, 1931.

The part of Dr. Moss's report records briefly the steps taken in the development of the wobble-meter and records of results obtained in preliminary trials of the improved type of instrument. The portion of the abridged report by Professors Swope and Brandenburg describes briefly the construction, standardization and application of the steadiness meter devised to measure the nervous reaction of a person as indicated by unsteadiness of the arm and hand.

Measuring Riding-Qualities

By Roy W. Brown¹

INITIAL efforts were made to measure vertical displacement. A seismograph shown in Fig. 1, developed by Dr. Benjamin Liebowitz, accomplished this for road service². In the laboratory, chassis were mounted with wheels running on heavy steel drums with obstructions bolted on the drum and displacements measured by chronographs³. Study of the records indicated that maximum acceleration was the most important factor; hence methods both mathematical and graphical were devised to differentiate the displacement-time curves. After much effort this was abandoned because of inaccuracies and extreme laboriousness of record interpretation.

Efforts made prior to 1924 to develop an instrument to measure acceleration directly, using a mass suspended by some form of spring, have been summarized by John A. C. Warner⁴. The Society published in pamphlet form in 1925 a bibliography of instruments and methods relating to riding-qualities with references to virtually all known acceleration-measuring instruments developed up to that time. The Bureau of Public Roads used an instrument of this type for determining impact on the

road caused by vehicle wheels passing over an obstruction⁵. This has now been replaced with an accelerometer of the contact-recording type.

Weight-spring-type accelerometers have not proved practical because of the error resulting from the natural

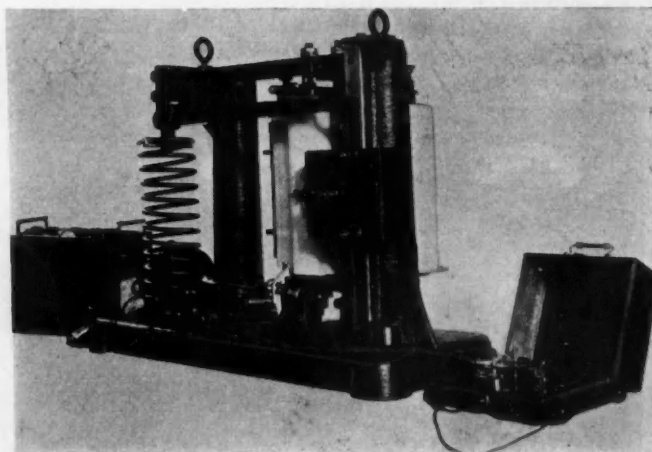


FIG. 1—LIEBOWITZ SEISMOGRAPH

Used to Record Vertical Displacement and Frequency. This Was One of the First Instruments To Provide Usable Information Regarding Motor-Vehicle Vibrations

¹ M.S.A.E.—In charge of engineering laboratories, Firestone Tire & Rubber Co., Akron, Ohio.

² See S.A.E. JOURNAL, January, 1920, p. 17.

³ See S.A.E. JOURNAL, July, 1925, p. 107.

⁴ See S.A.E. JOURNAL, July, 1924, p. 75.

⁵ See *Public Roads*, December, 1924, p. 1

period of the instrument approximating the period of the acceleration being measured. Design limitations are such that this effect cannot be eliminated in the range required for riding-quality measurements. The carbon-pile accelerometer using an oscillograph as a recorder is the only instrument having sufficiently high natural frequency (360 per sec.) to render the error unimportant. Notwithstanding numerous mathematical treatments which were later experimentally substantiated, numerous designs have been and still are made and sporadically used. The typically American idea of attempting to "get blood from a turnip" seems to have resulted in this case in the expenditures of large sums and appreciably delayed the ultimate solutions. It is encouraging to note that a recent instrument designed to measure vibration in tall buildings has avoided this pitfall by establishing a calibration correction curve of amplitude versus frequency⁶.

Contact Accelerometers Developed

The evolution of the contact-type accelerometer⁷ by the author in the Firestone laboratories was quickly followed by a contact instrument substituting a diaphragm for the spring by Dr. H. C. Dickinson, of the Bureau of Standards, and by the micrometer contact accelerometer by Dr. Benjamin Liebowitz⁸. These accelerometers, shown in Fig. 2, were rapidly developed into practical, accurate and rugged instruments suitable for continuous road service.

The substitution of a solenoid for the spring, as in Fig. 3, removed the last remaining objection to the use of the contact instrument; that is, the labor involved in securing, by hand, data from lengthy records⁹. Especially developed electrically operated counters were substituted for recording devices; thus, at the end of a test run, the counters need only be read, a few subtractions

⁶ See *Engineering News Record*, Feb. 19, 1931, p. 310.

⁷ See S.A.E. JOURNAL, December, 1925, p. 546, and June, 1926, p. 593.

⁸ See S.A.E. JOURNAL, March, 1926, p. 248.

⁹ See S.A.E. JOURNAL, June, 1928, p. 636.

FIG. 3 (BELOW)—FIRESTONE SOLENOID ACCELEROMETER

Six Elements Set for Different Values of Acceleration Are Combined To Make a Rugged Unit Adapted to Field Service. The Number of Accelerations Is Registered on Special Electric Counters

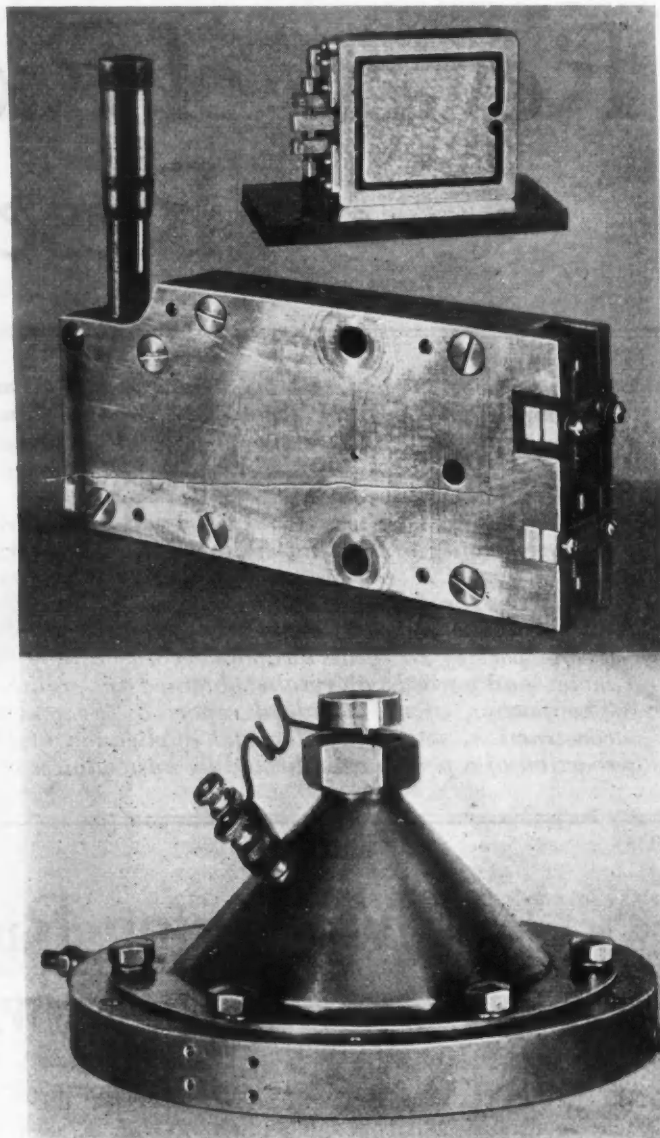
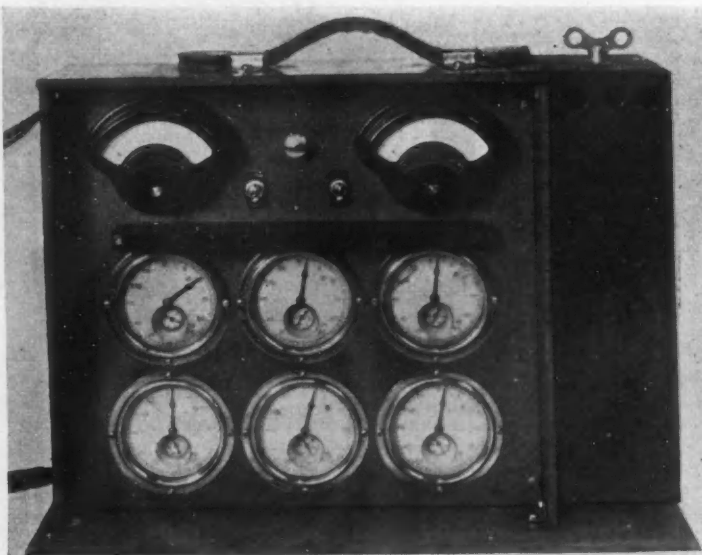
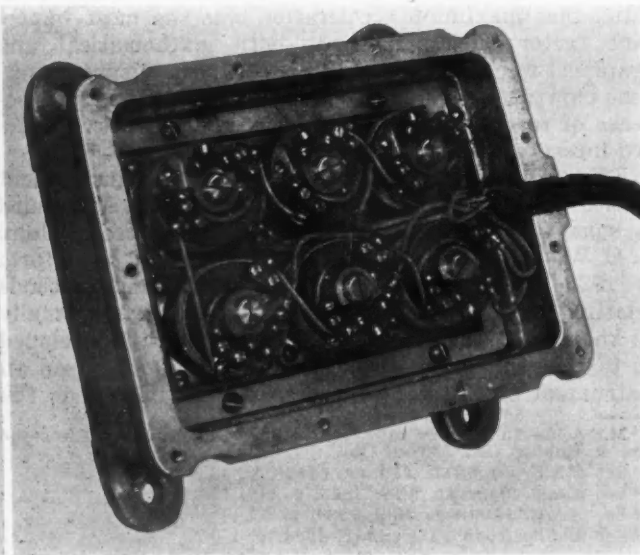


FIG. 2—EARLY FORMS OF CONTACT ACCELEROMETER

These Instruments, Separately Developed, Were the First To Eliminate the Natural-Period Error and To Accurately Measure Maximum Accelerations of Short Duration Occurring in Service



made, and the total number of accelerations and their magnitude are known.

This instrument made possible the determination of the number of accelerations occurring during long runs on which the total may be hundreds of thousands. The micrometer contact-type has been developed into a ten-element recording instrument by the Bureau of Public Roads and has operated very satisfactorily during the last year.

During the accelerometer development, two fundamental methods of dynamic calibration were evolved. A simple-harmonic-motion machine of elaborate detail design was constructed and later used extensively at the Bureau of Standards, where it now is. This provided definite means of substantiating various theories concerning accelerometers and served to eliminate a number of doubtful designs as well as establish the authenticity of dead-weight static calibrations. C. M. Manly and B. J. Liebowitz describe a rotating-weight method for obtaining harmonic motion which was tried out experimentally¹⁰. The use of the equipment described greatly clarified accelerometer instrumentation and indicated the solution of the problem of constructing a satisfactory instrument.

Numerous vibration instruments, with empirical calibrations, are commercially available. These should be avoided. Two meritorious methods of measuring velocity have been developed for application to mechanical

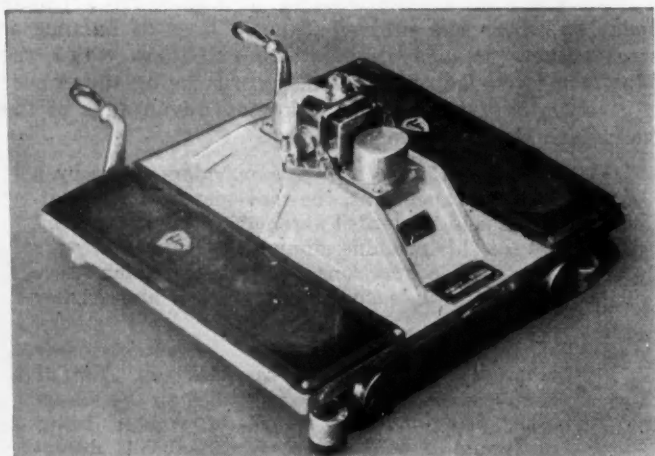


FIG. 4—MOSS WOBBLERMETER

The Platform on Which the Subject Stands Moves in a Vertical Direction upon a Central Pivotal Point as the Weight Is Shifted from One Foot to the Other and From Heel to Toe. This Motion Is Totalized and Registered on Two Counters. The Count Increases with Fatigue

equipment¹¹ which could be used for determining velocities of motor-vehicle vibration. However, work to date indicates that knowledge of velocity is non-essential.

Physiological Tests of Fatigue

Extensive use of the Firestone solenoid and the Liebowitz micrometer contact accelerometers indicates that motor-vehicle accelerations can now be measured quickly and accurately under actual service conditions. Measurement of accelerations being accomplished, it remains

¹⁰ See S.A.E. JOURNAL, August, 1927, p. 121.

¹¹ See *General Electric Review*, August, 1924, p. 511; also Paper No. 13, *The Journal of the Institute of Electrical Engineers of Japan*, May, 1927.

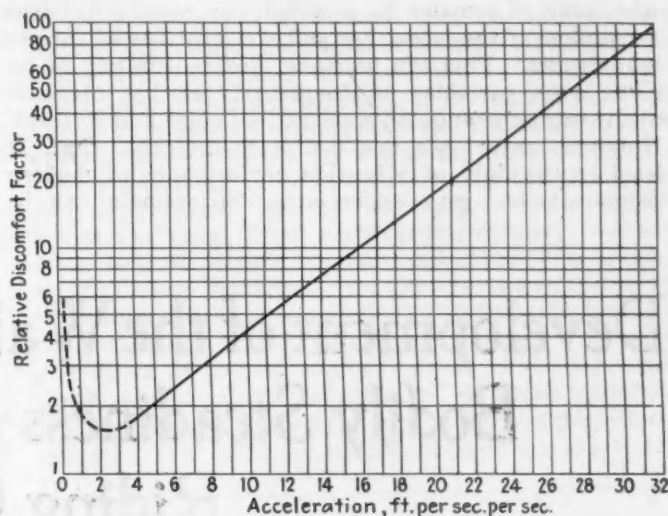


FIG. 5—HUMAN VIBRATION-SENSIBILITY CURVE

Experience Has Dictated the Usefulness of This Empirical Curve When Applied to Fatigue Resulting from Riding in Present-Day Vehicles. Researches Under Way Promise Data from Which an Accurate Curve May Be Derived

to determine their physical and mental effect. This portion of the work was placed in the very capable hands of Dr. F. A. Moss, of George Washington University, whose efforts have been concentrated upon finding an objective measure of fatigue that would be reliable, valid and free from subjective error.

First attempts along this line were confined to the known physiological tests of fatigue. Of these, the carbon-dioxide combining power of the blood proved most accurate. It was abandoned on account of the large sample (5 to 10 cc.) of blood required. After much experimental work, Dr. Moss found that bodily unsteadiness was an excellent criterion of fatigue. First investigations indicated simple tests, such as eye-and-hand co-ordination movements, to be unsatisfactory, as fatigue tended to lower the steadiness of the body as a unit. However, if the effect of fatigue is to be measured from only one portion of the body, it should be from the legs. This led to the conception of the wobblemeter, an instrument upon which the subject stands and which records in two planes the inability of a person to maintain perfect vertical equilibrium. The instrument, illustrated in Fig. 4, has now been developed into a compact, reliable and accurate form and is being made commercially available.

Prof. Ammon Swope, of Purdue University, has attempted a statistical study of the passengers' reaction to such items as seat cushions, upholstery, speed and tire noises. Efforts have also been made to measure fatigue by determining the minimum size of hole through which a stylus can be inserted without touching the edge of the hole.

What Remains To Be Determined

Riding comfort comprises as many factors as there are motor-vehicle passengers. Hence the engineer who anticipates accomplishing usable results for his organization must confine his work to the major elements; and these major elements must be viewed statistically. These researches have provided practical instruments for the measurement of acceleration and for the measurement of fatigue of motor-vehicle passengers. By

and large, it remains to establish the relation between sensibility of the passenger and accelerations of various magnitudes. This can be elaborated indefinitely to include such variables as frequency, velocity, displacement, rate of change of acceleration, noise and so forth. However, experience has definitely indicated that, at least in the light of vibration performance of modern motor-vehicles, very appreciable improvement can be

realized by assuming arbitrarily that the relative discomfort factor varies in proportion to the square of the accelerations at accelerations above 4 or 5 ft. per sec. per sec. (See Fig. 5.) It is to be hoped that fuller appreciation of the present significance of the major factors involved will enable greater practical application of the results of the riding-qualities researches which the Society has sponsored.

Development of the Wabblemeter for Measuring Bodily Steadiness as an Indication of Riding Comfort

By F. A. Moss, M. D.¹

WE HAVE GIVEN the name "wabblemeter" to the instruments devised for measuring bodily unsteadiness, the name perhaps being somewhat indicative of the purpose of the instrument. We previously designed a series of rather crude instruments for measuring this unsteadiness. All have consisted essentially in some arrangement for indicating ability to keep one's balance when placed on the instrument. These early instruments have been described in previous reports. Fig. 1, presented in this report, gives some indications of the results obtained with these instruments. The first three charts are wabblemeter records calculated by a stencil applied to the charted record on a graphic recording machine. The fourth chart shows results obtained in terms of oil pumped through an oil-pumping design of wabblemeter. (See Fig. 2.)

Results which we obtained, such as these, were considered sufficiently indicative to warrant further investigation. Accordingly, at the last Summer Meeting of the Society, a committee, consisting of R. W. Brown, Dr. H. C. Dickinson, and the writer, was appointed to devise a more practical instrument. It was hoped to

construct a reliable instrument which could be standardized and used in extensive tests of riding comfort. Due largely to the efforts of Mr. Brown, such as instrument is now available.

The new wabblemeter consists of a platform arrangement on which the subject stands. Loss of balance or unsteadiness is measured by the extent to which the platform is moved or wobbled, records being taken over a given unit of time. The following advantages of the new machine may be mentioned:

- (1) *Automatic Recording.*—The machine works by a lever arrangement, the movements of the platform being recorded automatically on two counters. This machine eliminates the necessity for electrical connections or for oil, which were necessary in some of the cruder and earlier machines.
- (2) *The machine integrates all the movements made when a person stands on the platform.* Two of the previous machines were based on the all-or-none principle, the record of wobble being maximum if sufficient to record at all; differences in records, therefore, occurred only with differences in the numbers of wabbles. In the new machine the record in count depends upon

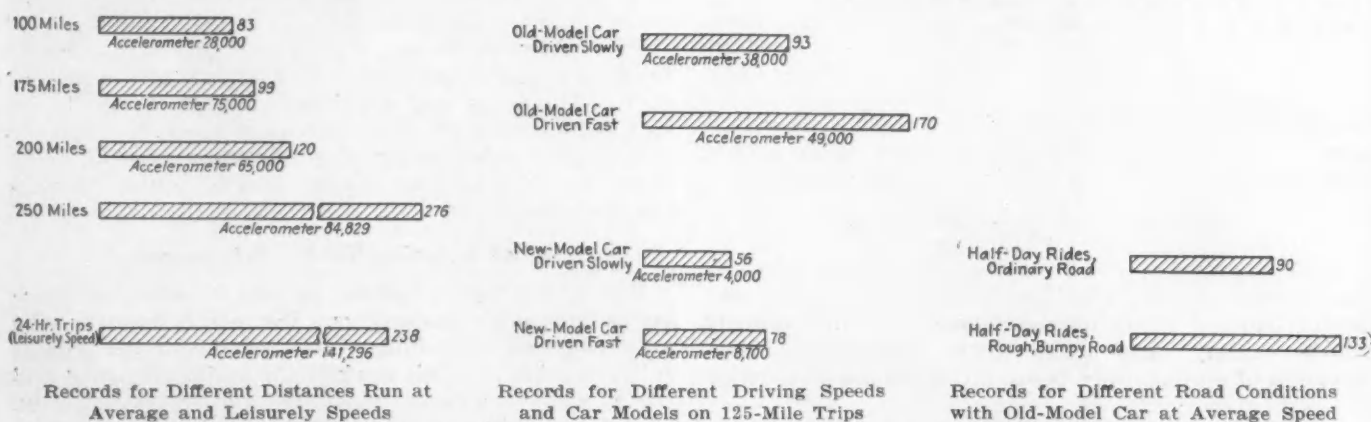


FIG. 1—WABBLEMETER RECORDS SECURED WITH CRUDE EARLY INSTRUMENTS

The Records Were Calculated by Means of a Stencil Applied to the Charted Record Made by a Graphic Recording Machine

the extent of the wobble. The smallest movements are recorded and all movements are recorded according to extent.

- (3) *Compactness.*—The instrument is very small, which makes for ease of shipment and transportation for road tests. It is self-contained, there being no extraneous batteries or other equipment necessary.
- (4) *The instrument is easily set up and easily used.*
- (5) *It is practically noiseless in operation.*
- (6) *It is not influenced by temperature changes,* or by other extraneous factors. Lack of this quality was a distinct disadvantage in some of our earlier machines, especially in the oil-pumping type.

With due care in using the new machine, in respect to taking of records and giving instructions to subjects as to correct standing on the machine, records with this new wobblemeter seem to be quite reliable.

Results Secured with New Wobblemeter

Since the new machine has been available for use only a relatively short time, the trials that have been made of it can be considered as only preliminary. Records taken on one long trip with six subjects are presented here as indicative of its usability. This trip consisted of slightly

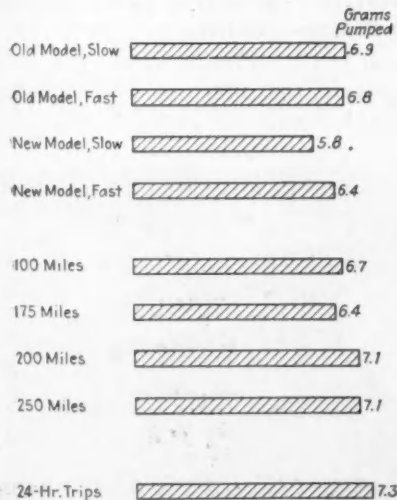


FIG. 2—OIL-PUMPING WOBBLER RECORDS

Results Are Expressed in Grams of Oil Pumped

tance driven. It is of some interest to note that some of the 100-mile units show more decrease in steadiness than other units of equal distance. The first unit of the day usually showed a greater decrease in steadiness than following ones. There also seemed to be some relation to time of day driven and intervening short stops. It is interesting, also, to notice the very marked rise in fatigue as measured on the wobblemeter for the 200-mile unit on the third day, which was made without a stop. For test trips where comparative records are to be taken of two automobiles, for instance, it would seem important to maintain the same conditions of driving.

Standardization of the machine for certain variables.—We have made a start in the establishment of standards on the machine which will make it more usable for securing subsequent fatigue records. These standards

are for variable factors in individuals who might be used as test subjects. It is desirable that the same subjects be used as measuring sticks in a series of tests. But where a large number of data must be collected in a short time, it may be necessary to utilize subjects coming in from long drives who have not had much previous experience as subjects for the tests. In such cases, it will be necessary to build up standards for taking into account certain of the individual differences which will act as variables in determining the results. We have made a very meager start on collecting data to show some of these variables. We are investigating the following variables: (a) *practice effect* in performance on the machine, (b) *sex* differences, (c) *age* differences, (d) *effect of weight*, and (e) *effect of height*. Inasmuch as many additional cases will be added to the ones we now have, it is thought best to delay publication of any standards until the additional cases are available.

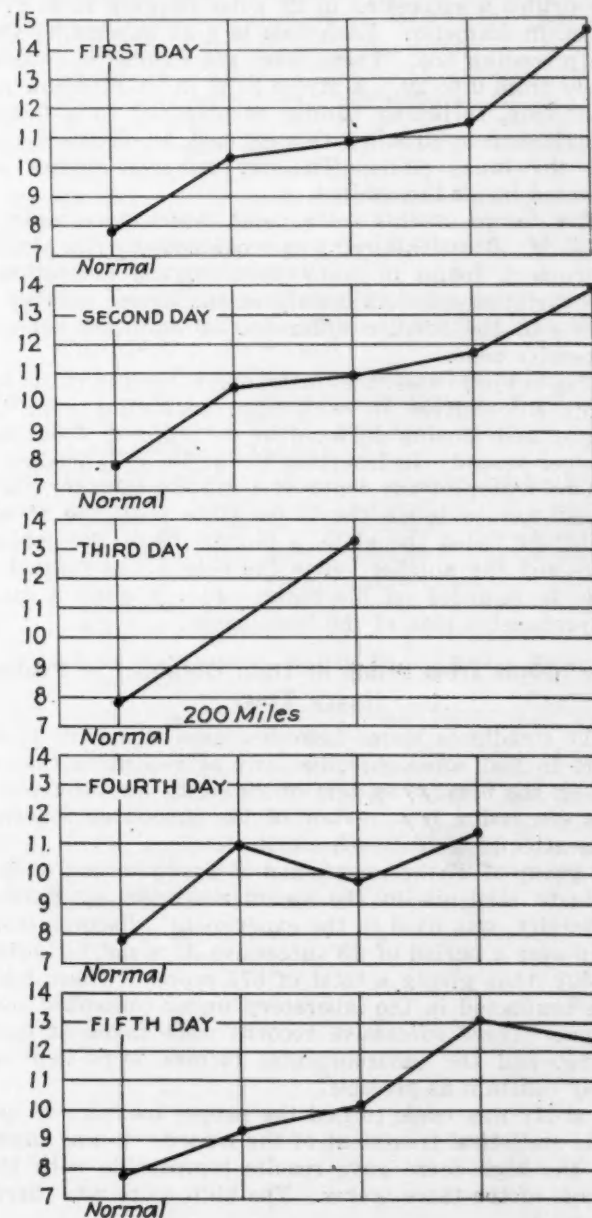


FIG. 3—RECORDS OF PRELIMINARY TRIAL OF LATEST WOBBLER

The Charts Represent Averages of Six Subjects on Successive Days of a 2000-Mile Trip

The Steadiness Meter and Its Use in a Preliminary Investigation of Riding-Qualities

By Ammon Swope,¹ in collaboration with G. C. Brandenburg²

THE STEADINESS METER is an instrument designed for the purpose of finding some objective means of measuring the nervous reaction of a subject under controlled conditions. It consists of a cabinet approximately 5 x 6 x 9 in., with a brass plate attached in the upper part at an angle of 30 deg. from the vertical. Through the plate, in two horizontal rows, are drilled a succession of 21 holes ranging from $\frac{3}{4}$ to $\frac{1}{8}$ in. in diameter. Each hole is $\frac{1}{32}$ in. smaller than the preceding one. These holes are numbered consecutively from 0 to 20. A stylus $\frac{3}{32}$ in. in diameter and 8 in. long, including handle, is attached to a flexible electric cord in circuit with a dry cell, an electric buzzer and the brass plate. The dry cell and buzzer are mounted inside the cabinet.

The design of this instrument, which was made by Dr. G. C. Brandenburg, is a modification of a similar instrument found in many psychological laboratories. The variation consists mainly in the larger number of holes and the smaller difference in diameter between successive ones.

The subject uses the instrument by inserting the stylus successively in each hole, beginning with the largest and moving forward at the rate of about one hole per second. In inserting the stylus it is pushed in to a back stop at the depth of 1 in., the operator being careful not to touch the brass plate with the stylus. Should he touch the plate, a buzzer inside the cabinet rings and the number below the hole where contact is made is recorded on his score. Fig. 1 gives a more comprehensive idea of the instrument.

Conclusions from Study of Data Obtained in Preliminary Test

The steadiness meter here discussed was built in an effort to find some objective way of recording the effect on the nervous system of riding in an automobile. This discussion is a review of the procedure followed in an attempt to find such a criterion.

A group of 27 men, composed of graduate and undergraduate students in the summer session at Purdue University, was used in the experiment. Records were taken over a period of 25 successive days not including Sunday, thus giving a total of 675 scores. These tests were conducted in the laboratory under controlled conditions. Three successive records were taken at each sitting, and the environmental factors were kept as nearly constant as possible.

A study was made to find the proper measure to use in the statistical treatment of the record. It was found that the high score gave results comparable with the average of the three scores. The high score was therefore used.

¹ Associate professor of industrial education, Purdue University, Lafayette, Ind.

² Professor of Psychology, Purdue University, Lafayette, Ind.

³ See S.A.E. JOURNAL, September, 1930, p. 355.

A statistical study of these data formed the basis for certain conclusions, as follows:

- (1) The steadiness meter measures with a high degree of reliability whatever it does measure.
- (2) The practice effect is small after the fourth trial and does not exist after the eighth trial when records are made on successive days under the conditions indicated in the foregoing discussion.
- (3) The variability from day to day is low for the group as well as for individuals.
- (4) It is apparent that steadiness of nervous reaction is one factor in making the record and that it has for each individual a fixed upper limit, as shown on the steadiness meter.

Use of Steadiness Meter in Preliminary Investigation of the Riding-Qualities

Findings in the use of the steadiness meter in a preliminary effort to ascertain the effect on the nervous system of riding in an automobile are here summarized.



FIG. 1—THE STEADINESS METER MOUNTED FOR OPERATION FROM THE FRONT SEAT

The Instrument Was Hung in a Rigid Position about 36 In. from the Floor of the Car. Its Position Required that the Operator Sit Forward on the Seat, thereby Having no Support for His Back

It should be clearly understood that this effect is measured insofar as steadiness of hand and arm is measured and is an index of such nervous reaction.

The meter has been introduced in the general study as a check on other methods which have been used or may be used in the future. In a previous report by Brandenburg and Swope, a rating scheme, which had been used in a preliminary effort to discover what to study, was explained and the data on 125 cases given³. This study led to a revision of the rating scale as an instrument to be used in the study and the standardization of the steadiness meter for the purpose of checking

against the subject reactions as given on the rating scale. In both cases the authors have made use of statistical methods of study with the belief that a critical statistical evaluation is more reliable than a judgment based on a few cases which may or may not be affected by unusual conditions.

Since no further data on the rating scale are available at this time, the report is confined to the evaluation of 160 person-trips under ordinary riding conditions through the use of the steadiness meter.

The steadiness meter has the advantage of being portable and may be used in any car at any time. Thus the records may be taken at the beginning of the trip and immediately after, in the normal riding position in the car.

Three readings were taken as explained in the first part hereof, and these were recorded on the record form. Immediately after the car had stopped at the end of the trip, the instrument was placed in position as before and three readings were taken and recorded. The mileage as shown by the odometer was given on the record form before and after the trip. The time was also taken to the nearest minute, as shown by the automobile clock. Such a record was kept for each successive trip. After the records were completed, they were filed away for statistical compilation at some later time. In some cases notations were made on the back of the card concerning any unusual conditions that might have arisen on the trip which would influence the record.

Six makes of cars from one to four years of age were used in these trials over territory which included 22 States. It should be observed that, insofar as the territory is concerned, the records were taken in plain and mountainous terrain. The roads traveled included virtually every type of hard surface and gravel roads. The major part of the driving was in the open country, although a small part was done in suburban and congested areas.

The records were taken, in the main, during the months of August and September, 1930. Nineteen persons, ten males and nine females, participated in making the records. They ranged in ages from 10 to 65 years. Seven teachers in the university, one director of engineering research, one public-school teacher, one homemaker, and five university and public-school students composed the personnel of the group.

Statistical Study of Records

After all the records had been returned, the necessary statistical compilations were undertaken. The first

⁴Due to a change in record form, the average was used in place of the high score. This in no way changes the consistency of the data in the paper.

major problem studied was the apparent effect on the nervous system of riding in an automobile. The procedure was to take the records of the trips, which totaled 160, and find whether there was any significant difference between the record made on the steadiness meter before the trip and the record after the trip. To do this, it was necessary to find the difference of the means and divide by the probable error of the difference. Of the three readings taken each time, the average⁴ was found and recorded as the mean reading for that time. After the mean readings had been determined, the arithmetic mean of the 160 average readings before the trip was found and also the arithmetic mean of the 160 average readings after the trip.

It should be observed that the simple and partial correlations and the prediction of the multiple correlation for both Meikle and Swope are consistent throughout, indicating that there is a fair degree of correlation between total miles traveled and the reading on the meter. In other words, the records indicate that the farther one travels the lower is his record on the meter.

Summary and Conclusions

- (1) The steadiness meter has been successfully adapted to use in an automobile.
- (2) The records obtained cover normal riding and driving conditions to a sufficient degree, 160 person-trips, to make the findings fairly reliable for this study.
- (3) The records obtained lend themselves to the ordinary methods of statistical treatment as used in mental measurements.
- (4) The effect of riding in an automobile is shown on the meter. A significant difference of 1.04 points lower after the trip than before is the average for 160 person-trips.
- (5) A study of the relationship between total miles traveled, speed, and readings on the meter shows nothing conclusive when total records are taken. The predictive value of the multiple correlation does show, however, that one of the variables, that is, total miles traveled, has a marked influence.
- (6) There is a marked individual difference in records made.
- (7) Mental attitude is an important factor in riding and driving an automobile.
- (8) In the study of individual records there is no significant relationship between speed and readings on the meter.
- (9) In the study of individual records there is a significant relationship between total miles traveled and readings on the meter.

Standardization Progress

AS ANNOUNCED in the April issue of the S.A.E. JOURNAL, meetings of the Aircraft and Aircraft-Engine Divisions of the Society's Standards Committee were held in Detroit on April 17 and 18 looking toward the completion of several new standards and the revision of some existing standards in time for approval at the Summer Meeting of the Society at White Sulphur Springs, W. Va., in June.

The work of the Aircraft Division is divided among several subdivisions. A subdivision of which John R. Cautley is Chairman has been cooperating with the Tire and Rim Association, Inc., on standardization of airplane tires, rims and tire valves. A revised series of tire sizes will include tires for airplane tail-wheels and additional sizes for landing-wheels.

C. H. Colvin is Chairman of a subdivision that has been reviewing the present S.A.E. specifications for airplane-instrument mountings with the view of bringing them up to date and in accordance with the Army and Navy standards.

In the class of structural materials, a subdivision of which C. E. Kirkbride is Chairman, has prepared recommendations for streamline and round tubing for both steel and aluminum alloys. The tubing for streamlining ranges from 2-in. diameter round tubing to 5-in. tubing in increments of $\frac{1}{4}$ in., the table including detail dimensions for the streamline sections. Round-tubing diameters ranging from $\frac{3}{16}$ to 5 in. have also been worked out for carbon and chromium-molybdenum steels and for aluminum alloys with wall thicknesses from #24 to #11 B.w.g. A supplementary table gives the section areas for round tubing, the weight per foot for both steel and aluminum-alloy tubing and the moment of inertia, the section modulus and the radius of gyration for the round tubing. Among other subjects prepared are brazier-head rivets in diameters from $\frac{1}{16}$ to $\frac{1}{2}$ in. and slotted shear nuts in sizes #10 to 1 in.

The Aircraft Division has been requested to consider establishing a standard opening in the floor of airplanes for aerial cameras, it being suggested that a single standard can probably be developed that will be equally satisfactory for military and commercial purposes and make it possible for all airplane manufacturers to provide a standard opening with a standard cover-plate in all airplanes.

New Aircraft Standards

Important Subjects Considered by Aircraft and Aircraft-Engine Divisions at Detroit Meeting

The Aircraft-Engine Division is completing a review of the splined-crank-shaft ends for mounting propellers and the addition of a No. 50 shaft-end in the present standard for larger engines. A No. 00 taper shaft-end is also in progress for small engines.

Time did not permit of publishing the proposed specifications outlined above as acted on at the Division meetings in Detroit before this issue of THE JOURNAL went to press, but it is planned that the completed recommendations as approved at the Division meetings will be published in the June issue.

Studying Tests for Rubber Products

WITH the increased use during the last few years of rubber products for mechanical purposes in automotive vehicles, the American Society for Testing Materials Committee D-11 on Rubber Products is developing abrasion tests on rubber products and expects to devote considerable time to this subject during the A.S.T.M. annual meeting in Chicago from June 22 to 26.

The Committee has made a few modifications in the present standard tests for chemical analysis to make them possibly a little less confusing to the

purchaser of rubber products. The subcommittee on Standard Procedure for Testing Rubber Products has been changed to the Subcommittee on Physical Testing of

Rubber Products. Some of the changes under consideration in physical testing are to make the maximum time after vulcanization in which the tests are to be made 60 days, and the length of time over which the tests may be made has been changed from 48 to 24. hr. The maximum room temperature to which rubber products are to be brought for test is 90 deg. fahr., and the article must be held in air of room temperature at least 1 hr. instead of 3 hr. as formerly. It is thought that this will require better air-conditioning in a number of the plants manufacturing mechanical rubber goods. The load on the thickness-testing gages was changed from 9 oz. plus or minus 1 oz. to 9 oz. plus or minus $\frac{1}{10}$ oz.

One of the more recent items taken under consideration by the Committee is the developing of a standard test for V-type fan belts, which was suggested by F. C. McManus, the Society's representative on the Committee. At present no common standard method for testing these belts exists. A uniform test should prove beneficial, especially to automotive-engine manufacturers who use this type of belting. Although no report was given by the Subcommittee on Vibration at the meeting of Committee D-11 in Pittsburgh on March 17 and 18, this phase of the work will be discussed at the Chicago meeting in June.

Ball-Bearing Standardization

New and Revised Recommendations Considered by Ball and Roller-Bearings Division

BALL-BEARINGS are without doubt one of the constructional items that have been most thoroughly standardized through the efforts of the Society and in the use of which the standards are most generally followed. Single-row annular ball-bearings of both the radial and the angular contact types have been established in standard sizes in the light, medium and heavy series for a number of years.

The Ball and Roller-Bearings Division is now considering adding to these

series a series of bearings of narrow, light type of comparatively large diameter to meet the requirements for bearings in which the saving of weight rather than the load capacity is of prime consideration. The bearing manufacturers have been furnishing this type of bearing for a number of years and, through the efforts of a subdivision, data have been gathered as to the dimensions of bearings of this type that have been furnished and a recom-

(Concluded on p. 588)

Production Engineering

Piston-Ring Making

Points on Design, Loading, Material, Casting and Limits Abstracted from Paper by A. J. Mummert¹

HEAVER loading of piston-rings, which is now being adopted by engine designers, throws a somewhat heavier burden on the ring material. Cast iron is still the accepted material, although it is not truly elastic, and the elasticity of piston-rings is very important. Considered only as a spring, some other material would be preferable; but the requirements of resistance to abrasion and distortion under operating conditions are equally important, and steel, bronze, aluminum and other materials have fallen short of giving the all-round satisfaction that is given by well-made cast-iron rings.

Few appreciate the wear-resisting qualities of cast iron. It resists galling and seizing extremely well at high speeds, with high pressure and even with poor lubrication, and it has been substituted for other materials in cases where distortion has caused trouble. Among the theories advanced for the high resistance of cast iron to wear and distortion are its high graphitic content and the peculiar structure of its matrix. While both of these factors probably play a large part, the graphite theory is supported by the good resistance to wear observed in gray iron having a considerable variation in the combined-carbon content and other structural features of the matrix.

Few materials are subject to more physical variations than is cast iron; it is only necessary to observe its various forms to realize the range of its possibilities; white cast iron offers better resistance to wear than does steel; soft gray iron is especially suitable for bearings and more malleable structures, such as pearlitic iron, can be obtained by varying the elements in the iron and the conditions under which it is cast. The production of piston-rings requires that advantage be taken of the resistance to wear and distortion that are offered by cast iron, and that it shall be produced in a way that will develop to the utmost its strength and elasticity. The modern individually cast gray-iron piston-ring serves as a good compromise which meets satisfactorily all of the requirements.

Methods of Casting Piston-Rings

Piston-rings are individually cast for three reasons: First, this method enables the maker to cast the ring in the

shape that is required to give the best results in operation. This shape can be secured by peening, machining or bending, but casting seems to be the favorite method. Second, individual casting is somewhat lower in cost than the older pot method. The third and most important consideration is that individual casting produces a dense structure that is uniformly strong. Considerable variation in structure was found in pot castings, particularly of the larger sizes. The cross-section of individual castings is uniform, the only possible variation being at the gate. The quick cooling of the small section contributes to the uniformity.

Use of the electric furnace for melting and refining the iron to be used in individually cast piston-rings is of considerable advantage, because it eliminates the source of most of the trouble experienced in cupola operation. Uniform conditions of melting and handling must be secured day after day if the product is to be uniform and losses are to be low.

The electric furnace is subject to less variation in operation than is a cupola, in which the material is subject to contamination during the melting operation. Some metallurgists claim that this contamination is due to oxygen and other gases in the blast, while others have hinted that it is due to some element which foundrymen have not been able to control. Be that as it may, elimination of the blast does greatly reduce these variations.

The electric furnace can be operated with a reducing atmosphere, so that any effect of moisture or gases in the air is virtually eliminated. Sprues, gates and risers from an electric-furnace melting are as valuable for remelting as is the original pig iron, while scrap from cupola melting usually brings a price which is 30 to 50 per cent less than that of the original material. The more exact control of the mixture and of the temperature enables the electric furnace to produce material of such uniformity that it is well worth the additional expense of melting.

Loading Studied in Deflection Tests

The practicable loading or unit radial pressure of a piston-ring is dependent upon the permissible fiber stress of the

material used, and the actual fiber stress is controlled by the thickness and gap of the ring. A desired ring loading can be obtained by designing a thin ring with a

large gap or a thick ring with a small gap; but the ratio of gap to thickness is subject to definite limitations to avoid subjecting the ring to greater stress when stripping it over the piston-head than when it is compressed in place in the cylinder. In practice, the width of the gap varies between 3 and 3½ times the thickness of the ring.

Much has been done in efforts to calculate the thickness, shape and other characteristics of piston-rings. Spring formulas that are so useful in other work could be applied if the material were truly elastic, but it takes a small permanent set for every load applied and a gradually increasing permanent set as the loads increase. This characteristic of the material and the small size of the section make a high degree of mathematical accuracy impossible.

Careful deflection tests on straight test-bars having exactly the same length and cross-section as the rings under consideration do, however, make it possible to study the behavior of the ring material under load. Comparison of such results with practical experience makes it possible to determine a reasonable factor of safety for loading ring sections of various sizes. Rings of small section are stronger and more elastic than those of larger section, because of their quicker cooling and denser structure. For that reason, relative loadings on the larger rings should be somewhat less than those that can be used on the small rings. Individually cast ring-sections of 20-in. diameter are seldom subjected to a fiber stress much greater than 1600 lb. per sq. in., while 4-in. and smaller rings may be designed for stresses of 32,000 lb. per sq. in. or more, the maximum depending upon the manner in which the ring is handled in the shop.

Formulas Have Limited Usefulness

After deflection tests and practical experience have given a rather definite idea of the limitations of the material, a few simple formulas can be used to relate the different variables, even though the material is not truly elastic. As specifications of three different kinds can be used to express the loading requirements of a ring, it is desirable that ready means should be provided for converting one to another.

¹ M.S.A.E.—Chief engineer, McQuay-Norris Mfg. Co., St. Louis. This paper was presented at a meeting of the St. Louis Section.

The three possible specifications are: (a) the radial pressure in pounds per square inch; (b) the tangential force required to close the ring to a specified small end-clearance, as measured at the gap by the pull on a cord; and (c) the diametral force required to close the ring to a specified small end-clearance, the force being applied across a diameter at 90 deg. from the gap.

Following are formulas showing the relationship between the three different ways of specifying the load and between the load and the fiber stress:

For the relation between the radial pressure and the tangential force required to close the ring to a small end-clearance

$$p = 2F/wb \quad (1)$$

For the relation between the diametral force and the tangential force required to close the ring to a small end-clearance

$$d = 2.56 F \quad (2)$$

The relation between the diametral closing load and the fiber stress at mid-section is

$$s = 2.34 db/wt^2 \quad (3)$$

Where

b = cylinder bore, in inches

d = diametral force required to close the ring, in pounds

F = tangential force required to close the ring, in pounds

p = radial pressure required to close the ring, in pounds per square inch

s = fiber stress, in pounds per square inch

t = thickness of ring, in inches

w = width of ring, in inches

Formula (3) is most useful, because it is more practical to specify ring loads by diametral closing-forces rather

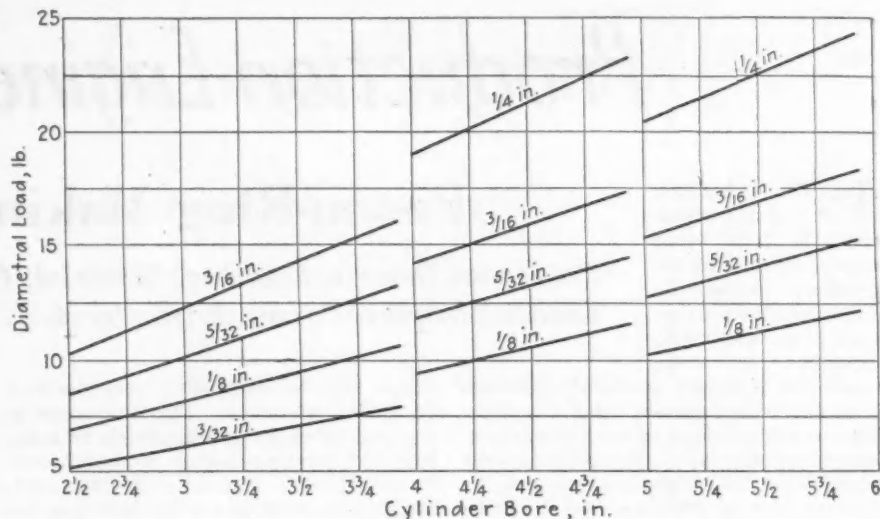


FIG. 1—PERMISSIBLE DIAMETRAL LOAD REQUIRED TO CLOSE RINGS OF VARIOUS DIAMETERS AND WIDTHS TO SMALL-END CLEARANCE

Each Line on the Chart Represents a Ring of the Width Indicated. This Chart Is Based on Formula (3) and the Following Data:

Bore, In.	Ring Thickness, Fraction of Bore	Permissible Fiber Stress, Lb. per Sq. In.
2 1/2-4	1/25 ± 0.005 in.	32,000
4-5	1/26 ± 0.0075 in.	30,000
5-6	1/27 ± 0.0075 in.	28,000

than by tangential or radial forces. Some engine builders specify the load which is to close the ring to cylinder diameter, instead of to a small end-clearance. The specification relating to small end-clearance is the more desirable because it gives consideration to conditions under a load greater than will be imposed in service. The "small clearance" used is ordinarily specified as 0.003 to 0.005 in.—just enough to be sure that the ends do not touch.

Fig. 1 shows graphically how the diametral ring-loading varies with the cylinder diameter and ring width. It

is based on formula (3), the ring thickness and permissible stress being assumed for the various bores as indicated. The fiber stresses chosen represent the maximum that is safe under average conditions or rings made by mass-production methods, but somewhat higher loads can be used with especially careful handling. The loads indicated in the chart represent averages. With manufacturing tolerances of ± 0.005 in. for the thickness of the smaller rings and ± 0.0075 in. for the thickness of the larger sizes, production variations of ± 1 to 1 1/2 lb. should be allowed. Of a large number of rings in current production that were examined, only one-half were found to be loaded as highly as indicated in Fig. 1. Ring thickness and loads may be expected to increase, to take advantage of the benefits to be derived from higher radial pressure, as engine builders are increasing the load requirements in their specifications for piston-rings.

Tables 1 to 6 summarize the dimensions and tolerances reported by engine manufacturers in reply to a questionnaire sent out in 1929. Practice in the different engines is represented in several of these tables by giving the occurrence or number of examples of certain limits or dimensions as a percentage of the whole number reported.

TABLE 1—AVERAGE THICKNESS OF PISTON-RINGS FOR VARIOUS BORES

Cylinder Bore, In.	2 1/4	2 3/8	3	3 1/8	3 1/4	3 3/8	3 1/2	3 5/8	3 3/4	3 7/8	4
Average Ring Thickness, In.	0.113	0.117	0.121	0.125	0.129	0.133	0.137	0.140	0.143	0.145	0.148

TABLE 2—MANUFACTURING TOLERANCES FOR PISTON-RING THICKNESS AND FOR PISTON DIAMETER AT BOTTOM OF RING GROOVES

Tolerance, ± In.	Occurrence, Per Cent Ring Thickness	Groove Diameter
0.0075	33	..
0.0065	6	..
0.0050	59	39
0.0030	..	34
0.0025	2	7
0.0020	..	13
0.0010	..	7

TABLE 3—CLEARANCE SPACE BACK OF PISTON-RINGS

Space Limits, In.	Occurrence, Per Cent Compression Rings	Ventilated Oil-Rings
0.055-0.065	..	13
0.045-0.055	..	13
0.035-0.045	..	13
0.025-0.035	25	35
0.015-0.025	75	26

TABLE 4—CHOICE OF RING WIDTHS, PER CENT

Widths, In.	Compression Rings	Oil Rings
1/8	44	5
5/32	8	7
3/16	32	58
1/4 ^a	16	30

^a Used mostly on trucks and tractors.

TABLE 5—WIDTH LIMITS FOR PISTON-RINGS OF DIFFERENT WIDTHS

Minus Limits, In.	Basic Width, In.	Occurrence of Limits, Per Cent
0.0020-0.0015	0.125	4
0.0020-0.0010	0.156	..
0.0015-0.0010	0.1875	..
0.0013-0.0003	0.250	..
0.0013-0.0008	..	23
0.0010-0.0005	..	42
0.0010-0.0000	..	50
0.0005-0.0000	..	57
..	..	39
..	..	19
..	..	11
..	..	17
..	..	23
..	..	8
..	..	15
..	..	15

TABLE 6—RING AND GROOVE CLEARANCES

Clearance Limits, In.	Occurrence, Per Cent Compression Rings	Oil Rings
0.0015-0.0030	22	22
0.00125-0.00275	5	..
0.0010-0.0025	52	52
0.00075-0.00225	17	10
0.0005-0.0020	4	16

Transportation Engineering

A SYSTEM of automotive transportation for intracity haulage and the movement of merchandise between railroad terminals, through utilization of tractor

and semi-trailer units and a thorough supervision of their movements, has enabled the Columbia Terminals Co., of St. Louis, to serve this city with a high degree of efficiency. On Jan. 1, 1931, the fleet comprised 102 four-wheel tractors, 440 semi-trailers, and 98 motor-trucks. At that time, 179 drivers and 80 drivers' helpers were employed.

Each semi-trailer stands as a unit on four wheels while being loaded and unloaded, the tractor, during the loading and unloading of the semi-trailers, being engaged in the hauling of other loaded semi-trailers. When a semi-trailer is loaded and ready to move, the coupling of tractor and semi-trailer is done automatically while the driver of the tractor remains in his seat. The tractor, backing up, lifts the front end of the trailer by engaging the guide wheel with the mounting tracks and the semi-trailer then locks to the fifth-wheel coupling-device on the tractor chassis. The same operation automatically releases the brake and elevates the two supporting wheels of the semi-trailer. When the tractor is to be released from the semi-trailer, the foregoing procedure can be reversed by the driver, who operates a lever in the cab of the tractor.

The practice of the Columbia Terminals Co. is to employ helpers on almost all of the fleet units to assist in loading and unloading merchandise. These helpers become qualified as drivers from experience gained in riding on the vehicles and associating with the drivers who are rated as such. However, before a helper can become a qualified driver, he must pass an examination given by the superintendent of the fleet.

Incentives to Safe Driving

An individual record of chargeable accidents is kept for each driver. The chargeable accidents considered are:

(1) Any personal-injury accident requiring medical aid and combined with lost time; that is, if any employee is injured and loses time from his regular daily work, it is regarded as a chargeable accident. Acts of God are not considered as being chargeable.

(2) Any damage to company property which exceeds \$5.

(3) All damages to other than company property, when the company's employee is at fault.

Accident Reduction Paramount

Large-Scale Freight-Haulage Company Demonstrates What Eternal Vigilance Can Accomplish

(4) All injuries to other than employees, when the company's employee is at fault.

Each driver who completes 12 months on the job without having had a chargeable accident recorded against him is awarded \$25 for his good performance. A bulletin board on which is recorded the number of consecutive days which have elapsed without having had a chargeable accident is displayed in each department. Each employee contributes by doing his bit to cause the number of "no-accident days" to mount as high as possible. It has been found that great regret is shown by any employee of a department who has been unfortunate enough or careless enough to wipe out a high-average record. Weekly bulletins pertaining to accident prevention and commenting upon accidents which have occurred are posted Monday morning in every department. Each employee is encouraged to read and familiarize himself with the contents of these bulletins, and to put into practice the suggestions and good advice which they display.

Accident-Prevention Committee Functions

An accident-prevention committee composed of employees chosen from different departments and representing different lines of duties meets monthly to discuss corrective measures. An important incentive to take interest in the work of this committee is that its members are paid for an entire day's work when they attend the meeting. If a

of each committee member is to spread accident - prevention propaganda as widely as possible among fellow employees with whom he may come into daily contact.

Minutes of the accident-prevention meetings are sent to every official and department head of the company, and also to past members of committees. In this way valuable suggestions, ways for eliminating risks, and decisions of the committee are transmitted to those concerned. Subjects relating specifically to safety in general are published in the attractive monthly magazine, *Columbia*, issued by the company.

Boxes for the receipt of suggestions from employees are located in all departments, together with suggestion-card blanks whereon employees can record their ideas for eliminating risks and bad practices.

As a result of five years of intensive campaigning for accident prevention, the record of this company, reproduced on this page, is impressive.

Handling Accident Cases

The Columbia Terminals Co. believes that the most important point in connection with accidents is that they be handled promptly. A report giving preliminary details of an accident is telephoned immediately to the company's claim department, recorded on an accident-report blank and placed upon the desk of the vice-president. It is usually not more than 10 to 15 min. from the time an accident occurs until a report has received the attention of this official.

When any serious or unusual accident

FIVE YEARS OF COLUMBIA TERMINALS CO. ACCIDENT PREVENTION

Year	No. of Employees	No. of Vehicles		Semi-Trailers	Personal Injuries	Property Damages	Total
		Motor-Trucks	Tractors				
1926	636	64	97	369	361	457	818
1927	680	68	101	400	203	298	501
1928	697	97	106	430	161	202	363
1929	692	98	111	440	176	102	278
1930	614	102	111	440	102	84	186

meeting is concluded at, say, 1 or 2 p. m., the members are then at leisure and can spend the remainder of the day as they please.

Members of the accident-prevention committee are appointed for only one year. Individual members may be re-appointed on succeeding committees, and this is usually a sign of meritorious work. One of the chief functions

occurs, the employee involved is brought to the general office. There, specially constructed models of automobiles, trucks, tractors, motorbuses, street-cars, streets and street intersections are available, as well as a supply of the different implements used in handling freight. By using these models, the employee can reenact the accident while the details are fresh in his mind. The

accident-prevention committee reviews each accident at the monthly meeting, discusses it in detail and makes recommendations when possible. In cases in which accidents are due to carelessness, neglect or failure to follow specific in-

structions, the employees involved are suspended from service for a period, the length of which depends upon the seriousness of the accident. An employee is seldom discharged because of having been involved in an accident.

in them points to some mistake in driving that the man is repeatedly making. If no clue is found in this manner, any similarity in several of the driver's accidents should be noted. It may be found, for example, that the man has many accidents while making right turns, or that most of his accidents occur at rush hours.

Truck Operators Practice Safety

Survey Reveals That Driver-Training Programs Reduce Accidents and Operating Costs

THE POPULAR belief that motor-truck drivers are a menace to the lives and safety of other highway users is disputed by facts developed in a survey being conducted by the National Automobile Chamber of Commerce. A tabulation of answers to a questionnaire circulated by the Chamber among the operators of motor-truck fleets indicates that fully 94 per cent of the truck owners insist upon careful driving by their employees.

More than 1000 fleet operators in charge of an aggregate of 33,881 trucks have already replied to the Chamber's inquiry. Of these, 44 per cent, or nearly half, have a definite program of driver training whereby they impress their employees continuously with the necessity for careful and courteous driving. The 44 per cent controls the operation of 74 per cent of the trucks figuring in the survey. Of the companies which reported, 94 per cent related that some effort was being made to encourage better performance on the part of their employees. Rigid examinations must be passed satisfactorily before an applicant will be employed by 66 per cent of the truck owners, and a course of instruction for new drivers is maintained by 67 per cent of the fleets.

Additional encouragement for good drivers is offered by 46 per cent of the companies in the form of salary increases, bonuses or other means, while 81 per cent of the fleet owners controlling 93 per cent of the vehicles penalize carelessness or recklessness by suspension or dismissal. More than 40 per cent of the operators regularly emphasize safety principles by displaying placards or distributing literature.

Questioned as to the accident records of their fleets, 575 companies had records available for the first six months of 1930, covering an aggregate mileage exceeding 131,550,000 miles, which showed an average of one accident to every 15,945 miles of operation. Of 448 fleet operators who reported having driver-training systems, 224 asserted that their systems had reduced accidents; 363 added that they had reduced operating costs, and 352 attrib-

uted increased business to the goodwill created by their drivers. — *Highway Spokesman*.

Re-Training Incompetent Drivers

IN NATIONAL Safety Council Pamphlet D-3 the statement is made that, in any group of drivers, regardless of how well they may have been selected and trained, some consistently will have more accidents than others. Such drivers may often be re-trained for correction of minor bad habits. The technique of investigating the drivers' shortcomings has been developed more highly by street-railway companies than anywhere else, and is being applied to motormen and to bus operators.

Accident records for each individual driver guide the work of re-training. A card can be used to summarize each driver's accident experience. When a driver has had more than a given number of accidents, say five or six in a year, the reports are examined carefully to determine whether anything

Observer Rides with Driver

An observer is then sent out with the driver to watch him while at work and especially to observe actions which might lead to the types of accident indicated by the reports. The observer may have to ride with the man for several days before he can report fully.

An interview with the driver, during which his accidents are discussed, may also help to bring out the causes. The interview should be a friendly one in which driver and interviewer cooperate in finding out why the driver had accidents and how they can be prevented. A special physical examination may be desirable.

With all facts in mind, a decision regarding accidents can usually be made. The driver may need more practice in starting and stopping smoothly, in turning corners or in backing. Adjustment of his working hours, route or type of vehicle may be necessary to avoid accidents which result from trying to drive in heavy traffic while seriously fatigued. In some cases the driver may have an antagonistic attitude toward his work. Experience has shown that this can frequently be overcome by careful individual attention on the part of supervisors, but in extreme cases discipline or discharge may be necessary. In any event, each case is a separate one and success is to be obtained by concentrating on the driving characteristics of the individual.

Standardization Progress

(Concluded from p. 584)

recommendation prepared that follows closely the dimensions already established in practice. This recommendation includes bearings ranging from a 10-mm. bore and 32-mm. outside diameter with a width of 9 mm. to a bearing of 110-mm. bore, 185-mm. outside diameter and 22-mm. width.

At the time the World War started, the Division was working on the formulation of a standard for a complete series of metric thrust ball-bearings but the war interfered with this program to a considerable extent. Although this style of bearings has not been used extensively by the American automotive industry, a number of recommended series have been published in the S.A.E. HANDBOOK for several years. In the

course of recent international standardization of ball-bearings, the Division has considered the simplification and modernization of these tables to more closely represent American practice in the manufacture and use of this type of bearing and, after protracted study, a subdivision recommendation is now being considered that includes tables of light, medium and heavy metric thrust-bearings of the single-direction, double-direction and self-aligning types. The complete recommendations of the Division on these subjects will probably be published in the June issue of the S.A.E. JOURNAL if they can be completed in time for presentation to the Society for final adoption at the Summer Meeting at White Sulphur Springs in June.

News of Section Meetings

(Continued from page 509)

the first burning gets so hot, the fuel does not stay burned, and the free elements unite again to burn a second time."

By means of experiments Professor Baender showed that flame will not touch a cold surface. Thus, water in a jacket of the engine keeps the oil film from burning and the cylinder-walls from scoring. With direct-cooled engines this is done with air, on the same principle.

"Automotive research work today is not concerned so much with the mechanical details," continued the speaker, "as with how to convert more heat into power. The use of dopes in gasoline is a makeshift; it does the work but it is not the final solution. We want to be able to use the fuel straight and also to prevent detonation. We are all striving for that, with a stock-car compression-ratio of 7:1 and higher. Flameless combustion offers the way out, I believe. It is as different from ordinary combustion as radio is different from the telephone."

Buffalo Section Hears the Romance of Rubber

BEFORE one of the largest gatherings ever held by the Buffalo Section, V. R. Jacobs, of the Goodyear Tire & Rubber Co., told The Romance of Rubber in his customary dynamic, rapid-fire way. The meeting was held at the Statler Hotel on April 7, and 240 members of the Section and their guests were present for the treat.

Preceding Mr. Jacobs' address, a very interesting and educational Goodyear motion-picture film of rubber-plantation life in Sumatra was run. Mr. Jacobs also had with him numerous samples of latex and crude and finished rubber with which to illustrate his talk. A much appreciated feature of the evening's entertainment was the showing, at the suggestion of Vice-Chairman William R. Gordon, of an unedited film of the new Navy airship Akron, now under construction by the Goodyear-Zeppelin Corp. at Akron.

Mr. Jacobs began his address with the statement that Christopher Columbus discovered rubber, presumably meaning that he discovered it to civilization, as he took some of the strange elastic balls of the American Indians to Queen Isabella of Spain on his return from his voyage of discovery to the New World. His enterprise was little appreciated, however, as no one could understand the peculiar substance and he was threatened with a prison

sentence. The first practical use made of rubber was as erasers for lead pencils. Charles MacIntosh conceived in 1803 the idea of coating fabric with rubber softened with turpentine as waterproofing material, but this proved unsatisfactory. No great utility of rubber was discovered until Nathaniel Haywood and Charles Goodyear discovered the process of vulcanization by mixing with sulphur and applying heat.

Today the rubber industry is a billion-dollar industry, not including an annual production of mechanical rubber goods valued at \$95,000,000, said Mr. Jacobs. More than 60 per cent of the world's output of rubber products comes from Akron, Ohio, although there is no good reason for that city being the center of the industry.

Rubber production has increased in 25 years from 60,000 tons to 800,000 in 1930. The middle East, Ceylon and the Federated Malay States today grow 95 per cent of the rubber. Whereas formerly each normal tree produced 4 lb. of latex per year, intensive cultivation and care have increased the yield to from 15 to 17 lb. The areas under rubber cultivation now aggregate 7,000,000 acres.

Mr. Jacobs injected much human interest into his narration by telling at length of the domestic, working and gambling habits of the natives who work the plantations. Although they are paid a wage of only 18 to 20 cents per day, they are able to save enough money during three years of work to retire, because the cost of living is so low.

Battery Improvements Depicted

Philadelphia Section Shown What Has Been Done To Meet Demands of Present Vehicles

THAT much-maligned accessory, the automobile storage-battery, had its day in court at the March meeting of the Philadelphia Section. Its defense was presented by L. E. Lighton, of the Electric Storage Battery Co., who presented proof, in the form of curves and figures, that the old black box under the seat has "evolved" almost as much as the automobile. Its improvement is not realized by most people, but the fact that it is able successfully to handle the largest multiple-cylinder engines of today without appreciable increase in size is one proof that improvement has been made.

This improvement, Mr. Lighton stated, is the result of better design and methods of manufacture. The greatest increase in performance has been in capacity and discharge rates at low temperatures. For example, the speaker showed curves for a 1914, a 1919 and a 1931 battery, all very similar in size and of the same ampere-hour rating at normal temperatures. At a 300-amp. discharge rate the voltages after 5 sec. were respectively 3.6, 4.1, and 4.2. More remarkable was a 390-per cent increase in time before the voltage of the latest battery dropped to the allowable minimum of 3 volts as compared with the earlier battery; almost four times the cranking time before battery exhaustion.

Not only is more demanded of the

battery today in starting effort, but it must supply a much greater current for accessories. The change from 21-cp. to 32-cp. head-lamps, which are being used to a greater and greater extent, presents a 40-per cent increase in lighting load. Add to this spot-lights, heating fans, sleet removers and other accessories, and a 20-amp. load is not unusual; some loads as high as 26 amp. have been found. With a generator capable of delivering only 16-amp. charging current, the battery gradually loses its charge unless a great deal of daylight driving is done, and finally refuses to start the engine.

Other factors tending to increase the difficulty of engine starting and for which the battery is frequently but unjustly blamed were stated by Mr. Lighton to be the use of too heavy an oil, low fuel-volatility and maladjustments of the electrical or induction systems of the engine. In addition to these are the usual fruits of lack of care and attention; the battery deteriorates, loses its capacity and trouble ensues.

The dealer also is often responsible for maltreatment which shortens the life of the battery, Mr. Lighton pointed out. A battery loses its charge gradually upon standing, as is generally known, yet many times a dealer will deliver a car that has been standing on the salesroom floor for months without a single recharging of the

battery. A battery in this condition frequently will start a car at show-room temperature, but fail at lower atmospheric temperatures and the life of the battery will usually be shortened. A battery in this condition needs a special charging rate that is lower than that given by the usual generator adjustment.

Low Temperature Reduces Output

As to battery characteristics, Mr. Lighton showed that low temperatures seriously affect battery output, and this, unfortunately, is the time when cranking demands on the battery are greatest. Some fully charged batteries that will give a 300-amp. discharge for 5 min. at 80 deg. fahr. before the voltage drops to 3 volts, will provide this discharge for only slightly more than 2 min. at 0 deg. If only half charged, this low-temperature interval drops to less than one-half. The discharge rate at 0 deg. fahr. is regarded by most people as the best test of the cranking ability of the battery and is being considered by the Electrical Division of the Standards Com-

mittee as a standard for comparison. Slower discharge rates at higher temperatures give no criterion of cranking ability. This was clearly demonstrated by the speaker with curves of batteries comparable in size and with the same rating at low discharge at normal temperatures. At the higher discharge rate and lower temperatures, the time before the voltage dropped to 3 volts varied more than 1000 per cent.

In selecting a battery, it is usual to consider the cranking load for the passenger-car. A battery so selected will successfully carry the normal lighting load. For motorcoaches it is usual to select a battery on the basis of the lighting load, which is so great that the cranking load assumes minor importance. Mr. Lighton predicted that, if the lighting and accessory load on automobiles continues to increase, it will not be long before automobiles will have to be considered in the same category as motorcoaches in respect to battery loading, and it will even be necessary to increase the generator output to keep in step with the greater current demands.

Engine Cowling and Cooling

Local Engineers Tell Wichita Section about Tests and N.A.C.A. Cowl and Townend Ring

THE March 23 meeting of the Wichita Section was held in the cafeteria of the Stearman Aircraft Co.'s new factory, where 50 members and guests sat down to the usual dinner and enjoyed the entire program, which was quite varied. Arthur Nutt, of the Wright Aeronautical Corp., and John A. C. Warner, General Manager of the Society, were guests of honor. The speakers of the evening were R. R. Higginbotham, project engineer of the Stearman Aircraft Co., and Herbert Rawdon, chief engineer of the Travel Air division of the Curtiss-Wright Co., of Wichita.

Mr. Higginbotham presented a paper that he had written, entitled, Engine-Cooling Problems with Venturi Cowling; and Mr. Rawdon gave a talk on N.A.C.A. Cowling and Townend Rings.

Cooling Standard Has Been Raised

Venturi cowling was described by Mr. Higginbotham as any cowling that entirely encloses the engine in an outer shell of circular section curving inwardly at the nose in such a way that the diameter of the front opening in the outer shell is materially less than is the outside diameter of the shell, the outer cowl extending a considerable distance to the rear of the cylinder center-line, whether the inner shell is continuous or not. This excludes the

Townend ring, and the term is used in preference to N.A.C.A. cowling because the cowls used in practice generally embody radical departures from the original recommendations of the National Advisory Committee for Aeronautics.

Mr. Higginbotham reviewed the standards of cooling under which the N.A.C.A. cowling was developed and the considerably lower temperatures which the Pratt & Whitney and the Wright companies now specify should not be exceeded in the operation of their engines. The importance of measuring engine temperatures in each new engine installation and the apparatus and methods of taking the temperatures were discussed. Major factors affecting engine cooling under the conditions of venturi cowling were divided into those independent of the design of the cowling and those directly dependent of the cowling design. The speaker remarked upon the strange fact that the recent tendency to increase the power of a given engine by means of higher compression-ratio or supercharging, without increasing the piston displacement or changing the cylinder design, has not presented any very serious cooling problems. This was attributed partly to the higher speed at which the more powerful engines drive the airplanes.

Cooling Affected by Various Factors

Engine-temperature effects produced by the grade of fuel used and by back pressure in the exhaust manifold were dealt with, and the speaker commented at length upon the importance of determining the correct area of the air passages. Tests made by the Stearman company definitely established that the entrance area required is not proportional to the horsepower and indicated that the depth of the curve of the outer shell has more effect upon speed, and the exit area has more effect on cooling, than has the entrance area. The effect of different lengths and curvatures of the inner shell, of intercylinder deflectors or baffles and of nose shutters on cooling and on speed were disclosed. Particular attention must be given to cooling the oil, said Mr. Higginbotham, and if correct design, location and ventilation of the oil tank do not suffice, some sort of oil-cooler must be provided.

Very little sacrifice in speed of the airplane was entailed by modifying original designs of cowling so as to give satisfactory engine cooling. The speaker concluded his paper with recommendations for designers who desire to lay out a venturi cowl for a 300 to 450-hp. engine in an airplane that is expected to have a speed of 140 to 180 m.p.h., but emphasized that they and the experimental data given apply only to nine-cylinder radial engines of this power range.

Mr. Rawdon, in his talk, brought out many interesting points about the N.A.C.A. cowl and the Townend ring. Wind-tunnel tests of a fuselage without an engine showed a drag of 28 lb., he said. Addition of a windshield and cockpit increased this to 40 lb., and the addition of an engine raised the drag to 133 lb. An N.A.C.A. cowl that will eliminate the additional drag of the engine should be considered 100 per cent efficient. The drag of the windshield or cockpit can be reduced but not entirely eliminated.

The fact that some cowls have been blown off in flight was attributed theoretically to the pressure inside being higher than that outside, the decrease in air velocity inside the cowl exerting a pressure outward while the partial vacuum formed by the flow of air over the outside also acted outward on the cowl.

An N.A.C.A. cowl of a design that is successful on one engine installation, said Mr. Rawdon, cannot always be used successfully on another airplane; it is somewhat of a cut-and-try problem.

Tungsten-Carbide Tools

A PAPER on the making and servicing of tungsten-carbide cutting-tools was presented at the March 26 meeting of the Dayton Section at the Engineers' Club by William H. McCoy.

The speaker, who is machine division manager of the General Motors Corp., handled the subject in an unbiased way and gave much practical information of value to production men. He placed emphasis on the importance of servicing the tools in the production plant and recommended having a centralized toolroom for the purpose and the appointment of a man especially to take care of the tools and see that they are properly ground. He also advocated having a supply of spare tools kept in good condition, so that haste in grinding would be avoided. He gave advice on how to grind the tools so as to procure, economically, a clean, sharp edge

having correct rakes and angles, without undercutting the edge or checking or cracking the tip.

Mr. McCoy predicted that tungsten carbide will play an important part in production in the future and said that great savings in production costs can be made if users of high-speed steels and alloys will be as sympathetic toward and exercise as much patience with tungsten carbide as they have with the high-speed cutting steels and alloys.

The meeting was attended by 42 members, a number of whom engaged in open discussion of the subject following the delivery of the paper.

Blind Flying Expounded

Southern California Section Sees Swivel-Chair and Air-Field Demonstrations with New Integrator

THE SESSION of the Southern California Section, held Friday, April 3, at the Alexandria Hotel, Los Angeles, dealt with what might be called the higher branches of engineering. The affair was billed as an Aeronautic Meeting, and one of the most interesting programs ever offered there held the interest of 116 members and guests until an hour past adjourning time.

This gathering was a representative one, containing many engineers and airmen and a goodly sprinkling of women. Among those who enjoyed the banquet and subsequent talks were Army and Naval officers, pilots, trade journalists, civil engineers, college professors and physicians. Two Japanese officials of the Nakajima Aircraft Works, Yokohama, added an international touch to the occasion.

Chairman Leigh M. Griffith opened the business meeting with a call for nominations of the ensuing year's officers and members of the Governing Board of the Aeronautic Division of the Section. The following names were proposed: Chairman, Gerald F. Vultee; Vice-Chairman, Harry A. Miller; Secretary, C. T. Austin; and Treasurer, J. J. Canavan, to serve with the outgoing Chairman, Mr. Griffith.

Standardization and Stress Analysis Urged

Stanley LaSha, chief engineer, aeronautic branch, United States Department of Commerce, delivered general comments on stress analysis in its relation to airplane manufacturing. He brought out the point that the prime object of the Department is to assure the safety and airworthiness of civilian craft.

The speaker admonished aircraft engineers to use utmost care in the preparation of their specifications so as to save time and expense, stating

that carelessness holds up production and invites unsafe construction. He urged the further standardization of small parts in aircraft manufacturing and explained that each ship now is made almost like a custom-built automobile, which makes the production cost high.

Major William C. Ocker flew from Kelly Field, Texas, with his aide, Lieut. Carl Crane, to present a paper on blind flying. He knows his subject thoroughly and delivered a talk, with demonstrations, that sent every member away better informed on this important business of aviation. The Major announced that actual demonstrations in blind flying would be conducted on the following day at the United Airport, in Los Angeles.

With his opening remarks, the Army officer gave a very illuminating demonstration with the aid of an ordinary swivel chair. He selected at random a pilot from the audience, blindfolded him

and proceeded to demonstrate how the senses, when deprived of visual reference, are the basest of deceivers. The subject, Waldo Waterman, a veteran of the air, was put through several experiments, and in each instance his senses played entirely false. Mr. Waterman was supplied with instruments, and, even with this assistance, his instinct as to direction and speed erred gravely.

Artificial Horizon To Fight Vertigo

Vertigo is the chief obstacle to overcome in flying without the advantage of sight. Accordingly, Major Ocker and Lieutenant Crane devised the flight integrator, a versatile instrument which is a boon to fliers lost in fog or total darkness. It consists of an artificial horizon and a miniature plane by means of which the pilot is able to ascertain the movement of his ship without outside aviation assistance in spite of his lying senses. The Major told of the Army's extensive interest in blind flying and used lantern slides to illustrate the use of the covered cockpit in training pilots at Kelly Field.

Discussion of the paper on stress analysis was contributed by Gerald Vultee, chief engineer of the Emsco Aircraft Corp., and by Waldo Waterman, who told of a shock-absorbing device that is under development which is claimed to increase safety by relieving wing stresses during maneuvering or in bad weather.

Blind flying interested several discussers. Ross McBride told how blind flying is taught to the cadets at Hancock College, Santa Maria, Calif., and Dr. I. H. Jones urged pilots to acquire more physiological information about the mechanism of their ears, eyes and heads, to be better able to overcome the fatal deceptions developed in the air by vertigo. In answer to questions, Lieutenant Crane said that the flight integrator which was displayed is not a completely developed instrument and that it will probably sell for less than \$1,000 when it is marketed.

British Columbia Meeting

Northwest Section Officers and Members Join Vancouver Engineers Planning New Canadian Section

AS A PRELIMINARY step toward the formation of a separate British Columbia Section of the Society, a number of members of the Northwest Section went to Vancouver, B. C., on the evening of Saturday, April 11, to hold a "sample" meeting with Canadian engineers at the Georgia Hotel in that city.

The Northwest Section, centering in Seattle, Wash., hopes soon to see the British Columbia Section a reality. In the offing for some future time is also the plan for an Eastern Washing-

ton or Inland Empire Section, centering about Spokane.

Those who went from Seattle for the Vancouver meeting were Don F. Gilmore, Section Chairman; C. H. Bolin, Chairman nominee for the coming Section year; Robert S. Taylor, George Webster, Reginald C. Pitzer, Al Jones and Roy Rossman.

Prof. A. G. Baender, of the mechanical engineering department of Oregon State College, was present as the principal speaker for the occasion.

The meeting was a big success. More

than 50 were present at the banquet, and by the time the lecture started this number was increased by 50 per cent.

Mr. Gilmore acted as chairman of the meeting and Mr. Boles acted as toastmaster at the banquet. A telegram of good wishes, received from John A. C. Warner, General Manager of the Society, was read. In it he congratulated the Society members in the Northwest territory for their excellent accomplishments and progressive ideas along automotive lines.

Mr. Taylor gave a talk on the S.A.E., telling what it is and its purpose and plans.

An interesting diversion was an impersonation by Mr. Rossman of a Spanish member of the Society from South America. He was at the speaker's table and fittingly acknowledged an introduction as a member from the Argentine. After a talk by Professor Baender on the modern trend of automobile design, in which the speaker discussed the introduction of eight-cylinder engines for automobiles, in 1913 or 1914, Mr. Taylor surprised the gathering with the statement that in 1907 there was an eight-cylinder car in Seattle, a statement which he said Mr. Rossman would substantiate. Then the "Spanish gentleman" arose and pulled off his whiskers.

Automobile Trends Discussed

Professor Baender discussed the 1931 trends as shown in the present models. American cars are largely used in Canada, so the discussion "hit home."

"The 1931 automobile is a wonderful thing," said the speaker. "We have seen gadgets developed to start it, and gadgets to stop it. There are gadgets to clean the windshields, to lock and unlock the engine, gadgets for free-wheeling and synchro-mesh gears for anti-shimmying." Factories have had time during the last year to concentrate on designs and refinements, more than on mere quantity production, declared the professor.

Trends of powerplants have been toward more cylinders, with several running up to 12 and 16 cylinders. Less noise, brought about by silencers and insulation of various kinds, is another trend. Compression ratios vary from 4.5 to 6.0:1. Oil-cooling systems and larger radiators have been developed to keep down the engine temperature. An oil passage drilled through the cylinder block to assure safe lubrication of the engine was pointed out as an important detail.

Down-draft carburetion was reported to be gaining in popularity. The history of free-wheeling, from its use in England five or six years ago up to the present time, and its introduction into American-made cars, was sketched hurriedly. Its advantages as (a) fewer revolutions of the engine, (b) less oil and gas consumption and wear, and (c) easy coasting on down grade. Dis-

advantages were discussed under the heads: (a) less electric current generated by the engine; (b) higher idling speed to prevent stopping of the engine, (c) danger of the cone slipping, and (d) more work imposed on the brakes.

Helical gears in transmissions were noted as another development more common in the new models. Improvements in rear axles, brakes, brake-rods and frames; deeper frames better braced; and designs of bodies showing

"air-mindedness" along lines of speed, are other trends pointed out by Professor Baender.

General car-trends were summarized as: bigger and more powerful engines; more cylinders, larger bore cylinders, and greater piston displacement; engine speeds creeping to 3200 and 3400 r.p.m.; crankcase ventilation about the same; all General Motors Corp. pistons made of cast iron; others of aluminum alloys; and greater valves, together with better performance.

Factors Governing Car Choice

Relation of Means to Needs and Desires Controls Selection, Summers Tells Canadians

WHY DOES a particular individual buy a particular car, in preference to others? C. E. Summers, assistant chief engineer of the Oakland-Pontiac division of the General Motors Corp., gave an interesting and extended analysis of this vexed question at the meeting of the Canadian Section at the Royal York Hotel, Toronto, on Wednesday evening, April 15.

The speaker said that it was a very ticklish matter to draw conclusions from the evidence which presented itself. For instance, a banker rolled by, sitting alone in the back of a big car driven by a chauffeur. Following him came a man and his wife and seven children and the dog, in a small rattle-trap. "We conclude from that," he remarked amid laughter, "that the second man for some reason of training or heredity prefers that car to ride in!"

With this illustration to demonstrate the folly of attempting anything in the nature of an exact analysis of such a variable thing as "customer's preference," Mr. Summers went on to exhibit an interesting chart on which he had mapped out the factors entering into the purchase of a car. First on the list came transportation, followed in order by economy, reliability, performance, style, comfort and exclusiveness. For the man with small means, transportation, economy and reliability counted for almost 100 per cent, with style, comfort and exclusiveness at almost zero. As the price of the car increased, so, in degree, entered into the picture the other factors in the order named.

We'd All Like Expensive Cars

Indicative of the trend of the buying public and the weight which must be attached to the factors he had enumerated, Mr. Summers said that at the close of 1930 two-thirds of car production was of machines selling below \$700. Putting the analysis on another basis, one-half of the production was of cars with four cylinders and one-

half of more than four; this was until the Chevrolet company switched to six. This did not mean that the preference of the mass of people tended to fours. It is very doubtful if a man were to be presented with a car free, that he would choose a cheap model! The basic fact is that transportation is a necessity to a great many persons. A carpenter, for instance, working at jobs on the outskirts of a city, is almost forced to have a car, and he looks round for cheap and reliable transportation. Apart from this the main-spring behind the tremendous development of the motor-car industry was the insistent urge to own a car and to experience the thrill of controlling power.

Alluding to the advantages and also the disadvantages of the larger and more powerful cars, Mr. Summers said that up to 16 cylinders there is a gain in luxury and smoothness, adding, "In my opinion, however, we will not go above 16 for a number of years, and perhaps not above 8 for any great volume of output."

No car, said Mr. Summers, possesses all the virtues. With the smaller cars one gets more noise and torque, but, on the other hand, with the big, smooth-running, luxurious limousine he might have to keep circling around the block for parking space until two Fords moved out together! Between these extremes, the other factors count with the buying public in varying degree, and even these known factors cannot be depended upon during a period of depression, when there is a general trend toward the cheaper car. All these things have to be considered in planning for two, three or four years ahead. "Perhaps, after all, a wild guess might be just as good," he concluded amid laughter, "but it is a lot of fun to analyze these things."

New Officers Nominated

The deferred report of the Section's Nominating Committee, presented by R. H. Combs, was as follows: Chair-

man, Frank B. Averill, factory manager for Durant Motors; Vice-Chairman, George W. Garner, chief engineer of General Motors of Canada; Treasurer, W. E. Davis, vice-president in charge of production for General Motors of Canada; Secretary, Warren B. Hastings, editor of *The Canadian Motorist*.

At the next meeting, according to Chairman Alex. S. McArthur, the members are going to take to the air on May 20. There will be three speakers: Col. W. A. Bishop, V. C., D. S. O., Canadian war ace, who will speak on aviation; R. G. Perry, general manager of the Colonial Coach Lines, who will speak on a new ski invention; and Prof. J. H. Parkin, of the department of physics of the National Research Council, Ottawa, an expert in aerodynamics.

Engine Lubrication Interests St. Louisans

SEVERAL out-of-town guests were present at the meeting of the St. Louis Section on March 25 at the Engineers Club. Among these were C. M. Larson, chief engineer of the Sinclair Refining Co.; Alanson P. Brush, a Detroit consulting engineer long associated with the automobile industry; John A. C. Warner, General Manager of the Society; and David Anderson, Secretary of the Detroit Section.

Mr. Warner gave a short talk on the scope of the Society, which has more than 7000 members and 20 local Sections in the United States and 1 Section in Canada. He stressed the importance of the local Section to the Society as a whole. He also showed some motion pictures of the National officers at work, saying that these men have all been identified with the industry for some time and occupy important executive positions in the leading companies engaged in automobile and aeronautic work.

Results of Road Tests on Oils

Mr. Larson presented a paper on engine lubrication in which he discounted some of the prevailing ideas on this subject. He exhibited slides showing the results of tests made in the Sinclair laboratories and on the road in test cars run in various parts of the Country. His paper brought out the factors that assure cold starting and satisfactory operation after the engine begins firing. Maximum viscosities for starting poppet-valve and sleeve-valve engines were given, as were also the minimum viscosities for their successful running without endangering the engine bearings. According to the figures given, the most satisfactory oil for an engine is one that has the highest viscosity consistent with starting requirements and ability to establish an oil film without delay.

The oil consumption per mile is less for the oils of higher viscosity. Speed plays an important part in the consumption, as shown by the following: A car was driven over a 100-mile stretch at average speeds of 30, 40 and 50 m.p.h., and the oil consumption at the respective speeds was at the rate of 1 qt. per 3200, 860, and 260 miles. Two oils of different grade but having equal viscosity in the engine under working conditions will show the same consumption. Thus, if in summer the crankcase temperature is, say, 180 deg. fahr. and an S.A.E. No. 40 oil is used and the viscosity under these conditions is 180 Saybolt sec., and in winter an S.A.E. No. 20 oil is used having a viscosity of 190 Saybolt sec. under the prevailing conditions, the consumption in summer and winter will be the same.

Mr. Larson's paper was of great benefit to the 100 engineers and oil men present, for he established the necessity for selecting oils primarily by their physical characteristics in actual operation, and not only by laboratory tests. Laboratory tests are necessary as a guide in making this selection, but a thorough knowledge of the engine is essential. Assuming the possibility of producing an oil that is chemically satisfactory and has sufficient viscosity and load-carrying ability, said Mr. Larson, the ideal oil

would have zero viscosity change for temperature variations throughout the working range. Since the last condition is probably impossible to meet, it is necessary to change grades to take care of the varying temperature conditions.

Oils Chosen by Temperature Charts

A. J. Mummert, chief engineer and vice-president of the McQuay-Norris Mfg. Co., showed some slides which bore out the results of the tests presented by Mr. Larson. Mr. Mummert described road tests that he had made with representative cars from which his curves were made. He attacks the problem of oil selection by plotting air temperature against crankcase temperature, then translating the crankcase temperatures into viscosity for various oils and replotting against air temperature. The second chart he arbitrarily divides into three sections representing winter, spring and fall, and summer. From these charts the oil suitable for each season can be chosen. A convenient indicator for a car is some form of viscosity meter that will tell the operator exactly what is going on within the engine.

The remainder of the evening was spent in a discussion of the papers and the personal experiences of the members.

Airplane-Carrier Operations

Lieutenant Webb Gives Wichita Section and Guests a Better Idea of Navy's Efficiency

WITH an address and motion pictures by Lieut. Leland D. Webb, U. S. N., as the attraction, nearly 100 persons attended the dinner meeting of the Wichita Section at the Allis Hotel on April 9. About one-half of those present were members of the local sections of the Women's Aeronautical Association and the National Aeronautical Association and the members of the Wichita Flying Club, who were the invited guests of the Governing Board of the Wichita Section of the Society.

While the main portion of Lieutenant Webb's talk was devoted to aircraft-carrier development, this officer found time to deviate now and then to tell other interesting facts about the Naval aircraft. One of the most interesting things mentioned was that a great sacrifice is paid by Naval ship designers for additional speed. As a concrete example, a ship that would do 30 knots would be powered with engines developing about 100,000 hp. With an extra 20,000 hp. they could do 32 knots, and for 2 knots' more speed they would need to have, and did in actual experience require, an additional 90,000 hp.

Another item of extreme interest

was that small ships known as destroyers have as much power as some of our fastest ocean liners. They are, in truth, floating powerplants.

Whereas the Lexington and Saratoga are mother ships for airplanes, each cruiser carries two fighting airplanes, which are launched by catapulting. These are used as "eyes" for the cruisers.

Interesting Facts about Carriers

Some of the statements made by Lieutenant Webb, who is now assigned to shore duty at the Bureau of Aeronautics at the Navy Department in the City of Washington, that were of most interest to his laymen hearers were as follows:

The present airplane carriers are the outgrowth of crude, makeshift decks built on the gun decks of cruisers.

The British Navy is credited with making the first attempt at landing an airplane aboard a ship.

The new carriers will be devoid of funnels and the entire deck will be used for landing and taking off.

These carriers are equipped with

hangars below the landing deck, and the airplanes that are to be repaired are lowered to this hangar deck on elevators.

The airplanes take off at the bow and land at the stern of the ship.

The pilot coming in to land pays little or no attention to the carrier itself but keeps his eyes on the signal man stationed on the carrier, who tells him in code by means of flags what to do and when to do it. Lieutenant Webb stated that it is very easy to land if the pilot does what he is told to do, but it is no feat for a novice to try. Before a pilot is allowed to land on board a carrier, he is given exhaustive training on land on a dummy carrier.

The arresting gear has been improved along with the landing decks, which are of steel covered with peat. The steel resists the shock and the peat makes movement about the deck safe in damp weather.

Much importance is attached to the pilots' keeping in contact with the carrier when the ships are off on a reconnaissance trip, as a slight deviation in the plans is often very serious.

Motion Pictures of Dirigibles

Lieutenant Webb showed several reels of extremely interesting motion pictures after his talk. These showed some of the lighter-than-air developments of the Navy, including the Los Angeles; the aircraft factory of the Navy, which is, in the main, an experimental station; student training; and early experiments with landing on board ship.

The evening was most enjoyable and educational to everyone present. The Governing Board of the Section was well pleased with the success of the meeting. Lieutenant Webb may be assured that the landlubbers in Wichita who were fortunate enough to hear him have a different idea of the Navy now than they had before and will do anything they can to assist those connected with the Navy. It is believed that the Navy would do well to sponsor such talks to be given at least once a year throughout the Country so that every citizen could see for himself what he is getting for part of his money that goes to the Federal Government.

Detroit Section Makes Merry on Ladies' Night

ASSEMBLED at the Book-Cadillac Hotel, March 23, were 500 members of the Detroit Section with their wives and friends. It was a brilliant, scintillating crowd compared with the usual "stag" meeting, and the very air sparkled with joviality. After an informal reception in the Italian Garden, the group adjourned to the Grand Ball Room, where dinner was served to the tune of a lively ten-piece orchestra.

Following introductions of the Gov-

erning Committee by Chairman P. J. Kent, Walter Dorwin Teague, one of the foremost designers in the field of graphic arts, was introduced as the speaker of the evening. He was formerly president of the Artists' Guild and four years ago entered the field of industrial design. Mr. Teague has been regularly retained by the Eastman Kodak Co. in charge of the styling and design of everything this company makes, and is retained also by the Marmon Motor Car Co. to design its cars throughout, so far as external appearance is concerned, and by a number of other companies, including the Union Carbon & Carbide Co. and Thomas A. Edison, Inc. The new Marmon 16-cylinder model is an example of his work.

Art in the Machine Age was the subject of Mr. Teague's talk, and his theme was that, for the first time in more than a century, we are developing an authentic style of our own and no longer need rely on the period styles of the past. "These latter," he said, "have been just so many toupées plucked from more fertile heads to cover the baldness of our own inven-

tion. Today we live in a machine age, an age of mass production, and, like it or not, the geometry of the machines has gotten into our eyes and our minds and influences all our likes and dislikes. As a result, we see a certain family resemblance appearing in perfume bottles and skyscrapers, automobiles and women's gowns, Frigidaires and jewelry; that is, we are creating our own style again, just as the ages of Louis XV or the Brothers Adam created theirs. And, by the time the world realizes that this is really what modern art means, we shall be living in a frame of beauty, heartily and gustily enjoying it, rich in the possession of authentic style."

Mr. Teague's talk was illustrated with a wide variety of pictures selected to prove his points. After the discourse, the Detroit Section danced to the lively music of the orchestra, the couples vying with one another through the intricate steps of the Rye Waltz, Circle Two Step, Robber's Dance and all the moderns. They were still going strong at 1 a. m., when the orchestra gave up trying to tire them out.

Cost-Reduction Methods Debated

Northern California Members Discuss Fleet-Operating Methods Presented by J. C. Bennett

REDUCTION of operating costs of motor-vehicle equipment was the subject of discussion at the April meeting of the Northern California Section, held at the Engineers Club in San Francisco on the evening of the 9th, following the customary members' dinner. James C. Bennett, manager of the automotive department of the Associated Oil Co., was the principal speaker, and he gave a paper along the lines of one which he presented at the Annual Meeting of the Society in Detroit.

Other speakers were Prof. A. H. Hoffman, of the University of California, who gave a short talk in which he stated that the agricultural engineering division of the University at Davis, Calif., is still investigating air-cleaners and oil-filters; and R. H. Stalnaker, equipment engineer of the California State Highway Division, who attended the meeting from Sacramento.

The meeting was attended by about 75 members and was presided over by Section Chairman E. H. Zeitfuchs, who announced that the May meeting, to be held on the 14th, would be devoted to new developments in the automotive-paint industry.

The Nominating Committee reported its selections for officers for the next Section year as follows:

Chairman, Howard Baxter, president and manager of the Howard Baxter

Automotive Service Co., of Oakland; Vice-Chairman, Arthur B. Domonoske, of Stanford University; Treasurer, Carl J. Vogt, of the University of California, at Berkeley; and Secretary, John R. MacGregor, of the Standard Oil Co. of California, of Richmond.

[Word has been received since this report was made that an Additional Nominating Committee functioning under Section By-Law SB-12 has nominated W. S. Crowell, of Edward Brown & Sons, as Secretary, and Edward Maybhem, of the City of Berkeley, as Vice-Chairman for the East Bay group. Ed.]

Maintenance Methods Discussed

Mr. Bennett's paper was illustrated with lantern slides and, at its conclusion, many persons took part in the discussion. In giving a resumé of his company's reduction of operating costs in the last three years, the speaker remarked on the intensity of use of each vehicle per year, which had increased by 20 to 25 per cent. Referring to the moot question whether an operating company should do its repair work in its own shop or turn some of the work over to private repair shops, Mr. Bennett stated that the company with which he is connected follows both methods, depending upon conditions. Depreciation of the equipment is charged on a basis of potential miles

during a period of 2½ years of intensive use and fleet continuity of service.

Mr. Bennett's Annual Meeting paper on the subject is tentatively scheduled for publication in the June issue of the S. A. E. JOURNAL, together with discussion on it.

Discussion by Edwin C. Wood, of the Pacific Gas & Electric Co., was read in his absence by Professor Hoffman and supported by S. P. Shaw, connected with the same company as Mr. Wood.

In answer to a question, Mr. Bennett stated that farming out repair work by many fleet operators is unsuccessful because it is necessary for the operator to have adequate supervision over the work and he must assume responsibility for inspection and for teaching the various outside shops what he wants, giving them a suitable standard to work to and advising them when to replace parts or allow partly worn material to remain in the vehicle. When first sending engines to outside shops, he had found that it cost from \$75 to \$100 more than to overhaul them in the company's own shop. When the private shops were asked about this cost, they said the installations were necessary to protect themselves against "come-backs." This excess cost was reduced by having a man go to the shop representative and inform him what was wanted to get a balanced job and sufficient repairs for the vehicle to continue in service. Success was attained by catering to shops that specialize on a particular part of the chassis, such as engines or electrical work.

Small Shops Give Best Results

Difficulty was met in using independent shops, such as those maintained by dealers. For instance, one truck agency refused to work on trucks of another make and, when reconditioning trucks of the make it handled,

could do so only according to the standard set up by the builder as a factory standard. Best results, according to Mr. Bennett, are obtained by using a small shop specializing in certain work and having a constant flow of work or a shop run "on a shoestring." The owner of the latter seems to assume the responsibility of the equipment as though it were his own and therefore excellent results are obtained.

The big, well-equipped, highly specialized shop was a great source of trouble because it was too highly departmentalized. This difficulty was overcome by having the shop designate a certain man to take charge of the trucks of the fleet that came into the shop, the fleet operator assuming the responsibility of training this man to the operator's requirements.

A question was asked as to what the size of a fleet in a territory should be before a company shop would be installed, and the reply was 10 to 12 pieces of equipment for one man to keep in repair.

Mr. Bennett stated that arriving at the right salary of a supervisor is difficult; if a man is changed from one territory to another, the mileage of the vehicles in the territory would be an equitable basis for payment.

The question of privately owned or company automobiles came up for discussion. Should the company pay the individual on a mileage basis? Should it allow him to purchase his own material or should it purchase the material at the fleet owner's discount and charge it at list price? The great difficulty is that some individuals owning cars will shop around to get repair parts as cheaply as possible, the shopping as a rule being done on company's time, while the conscientious employee buys parts at list price and saves the company's time.

500-mile race, the rules governing it and characteristics of the competing cars.

Derisive laughter was evoked by Mr. McCalmont during his talk, in which he pointed out the absurdity of filling-station attendants and garage men or the motorists themselves attempting to determine the excellence of an oil or the lack of it by looking to see how clean it is on draining, or to judge its viscosity or oiliness by the feeling of it, without first knowing anything of the temperature of the oil when at work and when being drained, or several other important points. He also ridiculed some lubricating-oil advertisements and other selling hocus-pocus by which motorists are deluded into the thought that they can judge the performance qualities of oils and alleged lubricating fluids, when even the laboratories are somewhat at a loss to ascertain certain qualities.

In leading up to the slides upon which his address was based, the speaker said that the car operator demands principally that engine oil shall maintain the required pressure on the gage, shall not be consumed rapidly, shall not thin out, and that it must not turn black or lose its pristine beauty; and this despite the facts that the pressure shows only how hard the oil finds it to circulate, that the higher car-speeds and consequent heat of the oil reduces the viscosity, and that after use a light oil looks very black in certain lights while darker-colored lubricants seem to change color much less with service in the crankcase.

Car manufacturers, on the other hand, said Mr. McCalmont, know that oil must give adequate protection to the working parts, must distribute reliably at all temperatures, and must not carbonize excessively, oxidize or be so heavy as to cause excessive power losses in forcing the oil through the circulatory system. Again, the higher engine-operating speeds and fast running, with resultant excessive heat, have made it more difficult for the oil manufacturer to supply oils that will adequately lubricate present-day vehicles and required a vast amount of added research and laboratory study to improve the performance characteristics of oils. This last has been done, however, and the oil man has at least kept up with the maker of cars.

Oil Research Keeping Pace

Laboratory men have recently adopted new methods of determining viscosity that aid in assuring the correct viscosity to afford full protection of the metal surfaces and keep down the consumption rate. The oil companies have increased the property of oiliness, which gives protection after the fluid film is ruptured, as it is a quality that causes a difference in the coefficient of friction during partial lubrication, said the speaker.

Resistance to evaporation is another important property to be considered

Oil Facts and Fancies

Hoosiers Told How Car Makers' and Users' Ideas Differ —A Formula for Fuel Consumption

ONE OF NUMEROUS dilemmas confronting oil-refining companies is the difficulty of supplying consumers with a lubricating oil having an intriguing and cosmetic-like appearance, which shall remain clear and unsoiled until it is drained from the crankcase and at the same time possess some at least of the performance characteristics that the motor-car makers demand as a protection of the engine from too great wear. This was the theme of an informal address on the subject, Performance Characteristics of Lubricating Oils, which A. W. McCalmont, manager of the manufacturers' service division of the Vacuum Oil Co., gave at the meeting of the Indiana Section on April

9 at the Hotel Severin in Indianapolis.

The evening was distinguished from the usual nature of the Section's monthly meetings by an entertainment during the dinner hour preceding the technical session and the showing at the end of the session of a three-reel motion-picture film furnished by the United States Bureau of Mines. The film depicted scenes in the oil fields of Europe and Africa.

Chairman Louis Schwitzer announced that the Speedway Race meeting of the Section will be held the evening of May 22, and that many of the Indianapolis Speedway officials and race drivers will be present to take part in the annual discussion of the coming international

and deserves more emphasis than has at times been given to it. Careful work in the laboratory is bettering this quality in present oils. A low rate of oil consumption cannot be obtained without due attention to cutting down evaporation losses. With present high-speed driving, satisfactory engine oils must also resist oxidation and gumming under high temperatures; otherwise there is danger of clogging the oil passages and restricting the supply.

The fast pace of present driving has given the oil men plenty of work, not the least of which has been to see that heavy-bodied oils, which are necessary for high-speed driving, perform without excessive carbon formation in city service. This requires careful refining.

The complicated battery of laboratory set-ups and testing equipment used by the refiners was shown in lantern slides by Mr. McCalmont, who made running comments on the views and the work involved in determining the underlying performance features of lubricants. In the laboratory tests supplemented by road testing, the refiner gets a very good check-up on just what sort of performance can be depended upon for his various grades and types of oil, and he is doing a better job than ever at this important work. One discussor of the paper said, however, that the more thorough the road testing is, the more positive engineers become that we are coming to know very definitely just what we do not know about lubrication.

Oldfield Presents Fuel Formula

Lee Oldfield, a prominent consulting and designing engineer of Indianapolis, gave a brief paper in which he presented a formula for gasoline consumption based on extensive long-distance tests of a dozen cars that have been undergoing lubrication tests. In checking gasoline-consumption figures at different speeds, Mr. Oldfield found indisputable evidence, he said, that consumption varied with all types of cars examined in direct ratio to the total travel of all pistons multiplied by the total travel of the vehicle. After a total distance of more than 100,000 miles had been traveled by a dozen cars, a curve was charted at 30 m.p.h. and another curve at 55 m.p.h. These curves were really straight lines, with the high gasoline consumer at the top and the low one at the bottom, and all the other cars fell practically on these lines. The formula finally employed was:

Piston strokes times number of pistons times axle ratio times revolutions of the wheels per mile.

The formula and the curves which seemed to prove it started a warm and incessant discussion that promised to run beyond the time limit of the meeting. All attempts to break down the theory fell flat. Neither the four, six or eight-cylinder cars departed more

than slightly from the curves of gasoline consumption based on the formula, which, as far as those present knew, had never before been propounded.

Kansas City Section Considers Diesel Engines

DIESEL-ENGINE development and operation was the subject of the evening at the meeting of the Kansas City Probationary Section on March 24. The dinner at 6.30 p. m. was attended by 39 members and guests, including John A. C. Warner, and 45 were present for the technical part of the evening's program. The speaker was J. H. Galloway, manager of the Kansas City office of the De La Vergne Engine Co.

In his handling of the subject, Mr. Galloway dealt principally with design details and the possibilities of high-speed Diesel engines. Development of the Diesel-type engine was illustrated with a series of lantern slides showing, first, the earliest types of internal-combustion engine and, progressively, the introduction of the Diesel principle and its progress up to and including present designs. Among the latest were shown engines ranging from 150 to 12,000 hp., including marine and stationary types.

Marked interest was displayed at the meeting in the possibility of forming a permanent Section in the Kansas City territory, and a number of applications for membership have been received.

Baltimoreans Are Introduced to Diesel Engines

MEMBERS of the Baltimore Section and their friends to the number of 161 were introduced to Diesel engines and Diesel principles at the March 19 meeting of the Section by C. L. Cummins, president and general manager of the Cummins Engine Co., who gave a splendid discourse on the subject. He showed his Diesel-powered racing car that has been entered in the annual 500-mile race to be run on the Indianapolis Speedway on May 30.

Pressed for the actual speed of the car, Mr. Cummins stated that it was capable of slightly more than 100 m.p.h., but he intended to increase the horsepower by improving the design of certain functioning parts and that this is expected to considerably increase the speed.

Mr. Cummins recounted the feats and performances that his various engines have accomplished, describing in detail the numerous trips made in his Diesel-engined cars, the actual fuel cost per trip, and spoke briefly about the troubles encountered in securing a license and insurance for his first car.

A series of lantern slides illustrating the Diesel principles used in his engine followed, the speaker dwelling on the three major stages of operation: delivery of the fuel to the injector, preparation and injection of the fuel charge, turbulence and final combustion. Interesting light was thrown on the subject of cooling. Although no radiator fan is used, no trouble has yet been experienced, in spite of frequently high temperatures.

"The flexibility of the Diesel engine and its ability to meet varying conditions of road and speed," said Mr. Cummins, "have been questioned, and the real object of our trips has been to test the engine in an automobile, because I know of no other application of an engine that presents so well every conceivable condition of load, speed and temperature. The automobile is doing more to make the public Diesel-engine conscious than anything else, and our greatest future seems to lie in the motor-truck and motorcoach fields. Our experience has developed unbelievable economy, which is due to practically level fuel-oil consumption per horsepower-hour at all loads and speeds."

The discussion following the talk lasted the greater part of two hours. Several members in the oil industry directed attention to and discussed pertinent characteristics of Diesel-engine oil. One of the guests, prominent in the employment of the Baltimore & Ohio Railroad, offered his opinion with direct relation to Diesel power for railroad use and assured Mr. Cummins that, with engines having an aggregate capacity of more than 750,000,000 hp. in use in the world today, Diesel engines offer something for the forward-looking man to think about. Interesting comment came from Mr. Vincent, superintendent of lighthouses, regarding operation and maintenance of the Diesel engines used by the Government in all electrified lighthouses in the Chesapeake Bay territory.

Electric-Furnace Cast-Iron

RESULTS obtained by the manufacture of cast iron in an electric furnace were most interestingly told in a paper presented by H. E. Bromer, of the Standard Foundry Co., of Racine, Wis., to which the Milwaukee Section, nearly 100 strong, listened intently at its March meeting, which was held at the Milwaukee Athletic Club.

This process is a comparatively recent development, and the speaker is a member of the Section. For this season's meetings the Milwaukee Section has secured within its own membership the talent that has contributed to most of its meetings, only two outside speakers having been required.

As usual, the meeting was opened

with a dinner, which was attended by about 60 members, who were entertained by one of the novelty teams which T. H. Elleman, Chairman of the Entertainment Committee, seems to have on call at all times. The discussion that followed the paper was interesting and at times exciting, and lasted for the better part of an hour.

New England Section Studies Traffic Control

TRAFFIC control proved a very interesting topic at the meeting of the New England Section on April 8. The meeting was held in the Walker Building of the Massachusetts Institute of Technology, in Cambridge, and some "Tech" students were among the 75 who were present. Section Chairman Albert Lodge introduced John A. C. Warner, General Manager of the Society, who spoke briefly in regard to the work of the Sections.

C. A. B. Halvorson, a consulting engineer, from the Lynn, Mass., plant of the General Electric Co., was the first speaker. He is widely known for his work on traffic control and has devised some of the control equipment that is in use in cities. After telling briefly of the spread of both manually and automatically controlled signals since their first introduction in New York City in 1918, Mr. Halvorson said in part:

"Formerly the only function of the signal was to allow traffic on one street to pass an intersection without interference and to allow traffic on through streets to proceed for a limited time without stopping. Since the system has passed its infancy, motorists demand an uninterrupted flow of through traffic; they ask that traffic toward places of business be able to move at a sustained high speed in the morning and that outward traffic have the same advantages in the evening; and they are not now content to wait long at intersections while no traffic passes.

"Pedestrians formerly had to be content to thread their way through vehicles making left and right turns. This condition has proved so unsatisfactory that traffic engineers in many cities have considered a period of the total cycle of the traffic light during which foot traffic alone should move."

Flexible Traffic-Systems Described

Mr. Halvorson then explained several systems which have been developed to meet these various demands. The flexible progressive system is the most efficient for moving traffic at a predetermined speed along through and cross streets and allows timing and adjustments for intersections. A recent development of this control permits ideal progression in one direction in the morning and in the opposite direction at night and average progression in

both directions at other times. Throwing a switch at a central point controls the selector, and this can be made automatic. Another modification of this system eliminates the expense of interconnecting cable by the use of synchronous motor drive for the timers. This does not permit variation of the cycle except by manual adjustment at the timer. A limited progressive system allows a reasonable progression by changing all lights simultaneously but showing opposite colors at alternate signals or groups of signals.

Traffic-Actuated Control, What It Is and How It Works, was the subject of an address by David L. Bacon, research engineer of the Automatic Signal Corp., of New Haven, Conn. He said that the system, which is based upon the momentary requirements of the traffic itself, flexibly adapting every green and red period of the light to best serve the existing conditions, is an engineering achievement of growing interest and importance.

Mechanical instruments giving the required regulation are entirely feasible, but a highly ingenious and infinitely flexible electron-tube timing circuit containing no moving parts and requiring no lubrication has resulted, according to Mr. Bacon, from an intensive study of the problem.

Dispatching equipment involves the use of a detecting device which reports

to the instrument the approach of all vehicles toward the intersection. Mechanical, microphonic, photo-electric or magnetic detecting devices can be used, but one which is said to be most satisfactory and now in general use consists of a pressure-sensitive package vulcanized in rubber and set flush with the surface of the street at a suitable distance from each corner. This type of detector informs the dispatching instrument of the direction and the approximate speed of an approaching vehicle.

As a measure of what can be gained by automatic control, Mr. Bacon said that the probable delay with fixed-time lights at an intersection through which 1000 cars per hour are passing will be 100 car-minutes per hour. Vehicle-actuated lights can reduce this probable delay to between 40 and 50 car-minutes per hour. Additional advantages claimed are that the peak capacity will be increased at least 25 per cent, accidents will be reduced 50 per cent and property damage will be reduced 65 per cent.

Lantern slides were used by both speakers to show the various systems of traffic control. The addresses were followed by questions which brought out additional information from the speakers, much of it regarding the colors of lights and the lenses used in traffic-control systems.

Hydrogenation and Tires

Washington Section Hears about New Fuel Process and Tire Manufacture and Service

PRODUCITON of 104 gal. of gasoline of any desired antiknock value from 100 gal. of crude oil is one of many possibilities of the hydrogenation process, asserted W. C. Bauer, senior mechanical engineer of the Standard Oil Development Co., who described this new refining process at the March 31 meeting of the Washington Section, which was held in the Washington Hotel. The other speaker of the evening was Clifford D. Smith, manager of product development for the Firestone Tire & Rubber Co., who gave many interesting facts about the development and improvement of motor-vehicle tires.

Nearly 100 members of the Section and their guests were present at the dinner which preceded the technical session. Prominent among them were Dr. George W. Lewis, research director of the National Advisory Committee for Aeronautics; Dr. H. C. Dickinson, chief of the heat and power division of the Bureau of Standards; and Dr. W. P. Herschel, associate physicist of the Bureau. A reel of motion pictures of various activities of members of the So-

ciety and their wives and daughters at the 1930 Summer Meeting at French Lick Springs was shown after the dinner.

The hydrogenation process, which was developed in Germany, involves the handling of large volumes of hydrogen under pressures up to 5000 lb. per sq. in. and temperatures up to 1000 deg. Fahr., explained Mr. Bauer. The oil and precompressed hydrogen are mixed and pumped through heating coils and then brought into contact with a catalyst. As virtually all the sulphur in the oil appears as hydrogen sulphide, hydrogenated fuels and oils have greater purity than those which are refined by ordinary processes, said the speaker. No coke is formed, and the plants can be operated continuously.

The plant at Bayway, N. J., which has been in operation for about four months, is the only commercial plant operating at present in this country. It has a capacity of 5000 bbl. of crude oil per day and is being operated as a subsidiary of the Standard Oil Co. of New Jersey. Another plant is under

construction at Baton Rouge, La. Most of the machinery for these plants was imported from Germany, as no satisfactory boiler tubes or pumps for handling large volumes of hydrogen at the pressure mentioned are available in this Country.

Hydrogenated products are characterized by their purity and stability. The fuels are "lead sensitive," that is, they are susceptible to the addition of tetraethyl lead, a small quantity of which causes a large change in the antiknock rating of the fuel. Hydrogenated gasoline is about equivalent to benzol for blending purposes.

Fuels produced by the process should not cost more than other fuels; as soon as machinery and other equipment have been acquired and put into operation, fuels of high antiknock value will be available to everyone, making possible the use of higher compression in engines and resulting in greater power and better economy.

Tire-Mile Cost Reduced 90 Per Cent

Automobile tires as much cotton tires as they are rubber tires, Mr. Smith told his hearers. He described them as "a flexible container of compressed air," and told of their development since their first invention. The methods of making the present cord balloon tires for motor-vehicles and the air-wheel for airplanes were explained as the chief reason for the greatly increased tire mileage now obtained. In 1910 the cost of 100 tire-miles averaged \$1.12, whereas now they cost only 12 cents, according to Mr. Smith. Not only has this cost been reduced by nearly 90 per cent in the last 20 years, but the quality of the tires has been so greatly improved that blow-outs or other troubles are rare.

Each cotton cord is impregnated with rubber in the Firestone process and each layer of all parallel cords is separated from adjacent layers by a layer of rubber. The composition of rubber used to insulate the cords, as well as that used for the tread and the side walls, has been greatly improved.

Sun, rain, or aging for two or three years does not injure modern tires. The ultra-violet rays of the sun and the ozone in the atmosphere cause a checked or cracked appearance on the surface of the tire, but this does no damage other than to the looks of the tire.

Balloon-tire tread-wear is affected by hot weather, high power, car speed, severe braking, neglect of inflation, various types of road surface, and by the amount of the unsprung weight supported.

Tread Wear Affected by Heat

Tire temperature is influenced by the temperature of the atmosphere and pavement, by road friction, internal friction and hot brakes. The brake-drum temperature is especially important with the present small wheel-diameters and the large drums necessary

with high-speed trucks and motor-coaches.

Tests have shown that tread wear is 300 per cent greater at 80 deg. Fahr. than at 40 deg.; 150 per cent greater at 40 m.p.h. than at 20 m.p.h., and 45 per cent greater at 125 b.h.p. than at 85 b.h.p., according to Mr. Smith. Identical tires have shown the same amount of wear for 18,000 miles in summer that they have shown for 33,000 miles in winter. To secure accurate test results, consideration must be given to all the factors affecting wear. A fleet of test cars in California is kept in operation day and night throughout the year. In a fleet of five test cars for a given test, each tire is given the same number of miles on each wheel of each car so that no variation due to wheels, cars or drivers will affect one tire more than any other. This method of testing has given very accurate and consistent results, said Mr. Smith.

With the increase in horsepower and speed of cars, a change from three and four-ply balloon tires to five and six-ply has been necessary to enable the tires to withstand the greater driving strains imposed upon them.

Proper care of tires always pays dividends, remarked the speaker. Adjusting the pressure during a run sometimes is worth while because of increase of pressure with heating of the tires. Too much inflation can do as much damage as under-inflation.

Tire size should be selected for the actual load the tire is to carry rather than for the load rating of a truck or motorcoach. In the case of dual tires, each pair should be correctly matched for height above the rim so that each tire will bear its proportion of the load. Worn tires should be placed on the inside of a pair, because of the crown of the roads.

Puncture-proof tubes are gaining in favor, said Mr. Smith. They are manufactured by placing a quantity of soft rubber on the outside, then turning the tube inside out so that the soft rubber is slightly compressed. These tubes seal all small punctures.

Non-Skid Airplane Tires

Airplane tires must be light but are required to withstand great shocks in landing and afford sufficient cushioning to prevent the crumpling of landing-gear and the breaking off of wings. The "air balloon" or air-wheel uses extremely low air pressure and in some cases has been used without any other shock-absorbing device. As brakes are now more generally used on airplane wheels, the tires are being made with non-skid treads, which have been found to add but little to the air resistance.

Tire manufacturers foresee no radical or spectacular change in pneumatic tires in the near future, said Mr. Smith, but continued gradual improvement of materials and construction undoubtedly will be made.

In answer to questions asked in the discussion, the speaker said that all that a tire manufacturer can do toward preventing shimmy is to make sure that the tires are in balance. A balancing machine is used to find the heaviest spot of the tire, and this is marked so that the valve stem of the tube can be placed at the opposite side of the wheel.

Answering other queries, Mr. Smith said that shock-absorbers usually improve tire mileage and that tires for racing are specially built. They have only a thin layer of tread rubber and very little or no rubber on the side walls. A heavy layer of tread rubber would be torn loose and thrown off by the centrifugal force.

Flying Down to Rio Described for Chicago Section

AT THE APRIL meeting of the Chicago Section approximately 120 members and guests heard Capt. A. W. Stevens, of the Air Army Corps, describe the 8000-mile flight from the City of Washington to Buenos Aires and return. Chairman E. W. Stewart presided over the meeting, which was held at the Hotel Sherman, Chicago, on April 9.

Captain Stevens' remarks were practically the same as those that he made at the February meeting of the Dayton Section in telling about this flight, which was sponsored by the National Geographic Society. They were supplemented by numerous lantern slides, some of which were reproduced from photographs that had been taken when the airplane was more than 300 miles from the objects shown. The greatest distance at which a photograph has been made in this Country was 270 miles, the speaker said, but better atmospheric conditions, the greater height of the Andes and the fact that a broad stretch of pampas lay between the airplane and the mountains being photographed enabled satisfactory negatives to be obtained with the camera farther away. In one instance Captain Stevens had to wait approximately six weeks to photograph some of the mountains and the result was possible only after he obtained permission to use a supercharged air-mail plane.

During the meeting Chairman Stewart announced the results of the voting for Section officers, as follows: Chairman, O. R. Schoenrock; Vice-Chairman, L. V. Newton; Secretary, Harold Nutt; and Treasurer, C. J. Blakeslee.

The May meeting of the Section will be held at the Midland Club, Chicago. Two papers are scheduled for presentation, one on Engine Carbon Formation, by J. O. Eisinger, research engineer of the Standard Oil Co. of Indiana, and the other on Toxic Effect of Exhaust

Gases, by A. H. Vance, a chemist of Bensenville, Ill., who has done considerable research work on this subject.

Clevelanders Visit Akron

ONE of the most successful Cleveland Section meetings of the year was held at Akron, Ohio, on April 20, when 170 members and their guests visited the great airship dock of the Goodyear-Zeppelin Corp. and inspected the huge Navy airship, Akron, now fast taking shape.

The Cleveland Section visitors were guests of the Akron members, about

30 of whom met them and went with them through the hangar, where a representative of the Goodyear-Zeppelin Corp. explained from the air the design and construction details and methods of the great 6,500,000-cu. ft. dirigible.

Following a dinner at the Firestone Clubhouse, V. R. Jacobs, assistant sales manager of the corporation, addressed the visitors on the subject, This Zeppelin Business.

The Cleveland Section Nominating Committee reported on candidates recommended for office for the coming Section year. The election is to be held at the May meeting.

Factors in Highway Safety

Beecroft Discusses Accident Causes and State Laws at Metropolitan Section Meeting

BRAKES and Their Relation to Highway Safety was the topic of Past-President David Beecroft's address to Metropolitan Section on April 16 at the A.W.A. Clubhouse, New York City. While his affiliations with the Bendix companies in various executive capacities qualify him as an expert on brakes, Mr. Beecroft's discussion of the problem of highway safety was based on a broad consideration of all the factors involved.

Preceding the talk, a truly remarkable exhibition of gun-play was given by "Texas Jack" Sullivan, the world's fastest pistol shot. Using a single-action Colt's 44-40, he demonstrated the hammer-fanning hip shot, the weapon being jerked into a horizontal position on the hip with the right hand while the left hand makes a lightning-like sweep across the top of the gun-barrel, "fanning" the hammer back and letting it fall, firing the weapon. His "broncho reverse" was as surprising as were the blank cartridges he fired unexpectedly and as amusing as the stories he told of the old West. "Texas Jack" received his early training with the "six-gun" from his father, "Broncho John" Sullivan and "Bat" Masterson, who were prominent figures around Dodge City, Iowa, during the gun-fighting days.

Mr. Beecroft, who needed no introduction, said that we hear a great deal about the need for city and State inspection of motor-vehicles as a solution of the highway-accident problem. We even hear talk of compulsory inspection before issuance of car-registration certificates and an idea of this sort has great popular appeal. Yet, when all is said and done, the fact remains that only 10 per cent of the fatal accidents are caused by vehicle defects, so there is grave doubt that a compulsory routine inspection of cars,

trucks and buses would assure any safer highways than exist today.

May Need Simple Automatic Controls

Since 90 per cent of the accidents are caused by drivers and pedestrians, concentration on their faults should yield the greatest results in any safety campaign. This may require manufacturers to devise simplified automatic controls and greatly improved signal devices. The statement by Robbins B. Stoeckel, Commissioner of Motor Vehicles of Connecticut, that inattention on the part of drivers causes one-half our accidents merits some thought by the automotive industry, Mr. Beecroft said.

The reaction time of car operators was discussed at some length, with reference to Dr. Moss's well-known wobblemeter. It was brought out that, because of increasing speeds, reaction time is most important in any determination of safe stopping distances. The effect of alcohol was mentioned.

Charts were shown for the relation of accidents to car registrations, for the causes of accidents, for car defects and for the part pedestrians play in the accident drama.

Returning to the question of compulsory inspection, Mr. Beecroft told of the difficulties met in securing any effectiveness from the Pennsylvania law, which he intimated is a failure. He told of the situation found to exist in Harrisburg and the impracticability of limiting the appointment of "official stations" to those with proper equipment and competent staffs. We must see to it, he said, that our legislators do not write into the laws any restrictions that will hamper motor-car development. The factory engineers are usually four or five years ahead of legislation and know best what are the technical requirements for the safest

motor-cars. If each State is to adopt standards, they should be established by some National organization like the Bureau of Standards, Mr. Beecroft suggested.

In the discussion, Dr. F. C. Stanley, of Raybestos-Manhattan, Inc., confirmed the statements previously made about the importance of driver reaction time, saying that in his brake-testing work he has found that at least 2 per cent of the operators cannot apply brakes promptly on signal.

W. S. James, of the Studebaker Corp., recited the sad story of the man who defended his right to the right-of-way. Mr. James went on to tell of road driving-tests, explaining how the Studebaker company has cut down accidents by eliminating road testing on Saturday afternoons and Sundays. He pointed out that the manufacturer is the first one to know of any defects in his product and that if complaints are made on 2 per cent of the output this is regarded as very serious.

Lieutenant Andrews, of the Police Department homicide squad, gave his own views on vehicle inspection and told of the investigation work by the department.

Metropolitan Section's next meeting is scheduled for May 28, with Diesel Engines as the subject. If pending arrangements are satisfactorily concluded, the meeting will be held aboard the motorship Milwaukee, and F. Van Rossen Hoogendyk will be the principal speaker. The Section is planning an outing to Fort Hancock at Sandy Hook, N. J., on June 6 at the invitation of Col. J. C. Johnson.

Syracuse Section's Final Meeting

AT THE Syracuse Section's final meeting of the season, on April 8, V. R. Jacobs, of the Goodyear-Zeppelin Corp., addressed a group of 78 engineers on the recent progress of lighter-than-air craft. A film was shown illustrating early types of balloons and rigid airships and their history was sketched. The major part of the evening was spent in a consideration of the Navy's new dirigible, the Akron, now nearing completion. The film released by the Navy Department just a few days before the meeting was exhibited and explained by Mr. Jacobs.

The Syracuse Section was prepared for a fast talker and Mr. Jacobs' entire speech was taken down on phonograph records. Harry Mattison, recording manager of the Clark Music Co., was largely responsible for the success of this experiment.

Results of the Section election were announced by Chairman E. S. Marks as follows: Chairman, Charles P. Grimes; Vice-Chairman, Richard N. Wright; Secretary, Lloyd M. Moulton, re-elected; Treasurer, Melville R. Potter, also re-elected.

Council Analyzes THE JOURNAL

SPECIFIC suggestions of the Society's Publication Committee, aimed toward a detailed improvement of the S.A.E. JOURNAL, were discussed by the Council at its meeting in Detroit on April 17. It was felt that THE JOURNAL could be made more effective by a greater compactness of its principal articles and that the various departments now included in THE JOURNAL should be perfected from the standpoint of more concise handling and better composition.

In answer to a resolution transmitted to the Council by the Annual Nominating Committee, it was decided that the Sections should be asked to select each year at least two alternates in addition to the regular representatives, in order that the entire membership of the Society be properly represented in the selection of nominees for the various offices of the Society. It is the hope that the selection of additional alternates may eliminate the difficulty that has occurred on some occasions when full representation was not present at meetings of the Nominating Committee.

The Council directed specific attention to the financial matters of the Society and noted an improvement in March in revenue from JOURNAL advertising.

Specific thought was given to the plans for the Summer Meeting at White Sulphur Springs in June, and

ideas were consolidated for making this event more than outstanding as a vehicle for the dissemination of engineering material that will be of value to all concerned.

A gratifying number of applicants for membership in the Society were approved.

Among Section matters discussed were the activities of our members in Kansas City, where efforts are being made to establish the nucleus for a regular Section of the Society. Definite recommendations regarding the proper handling of Student Branches were made.

Practically all major activities of the Society were reviewed, and suggestions were offered by Council members for the proper advancement of various lines of endeavor.

Milwaukee Two-Day Spring Production Meeting

MAY 7 and 8 are the dates and the Hotel Schroeder, Milwaukee, is the place of the Spring Production Meeting. This is right upon us and if anyone intending to go has overlooked making arrangements, this will serve to remind him that he should get his railroad tickets at once and have the laundry send home his clean shirts.

This is a combination Milwaukee Sec-

tion and National Meeting, with four technical sessions, a visit to the A. O. Smith automatic frame-production plant, demonstrations of new developments in the surface hardening of steels and in high-speed milling with tantalum and tungsten-carbide cutting-tools at the plants of the Hevi-Duty Electric Co. and the Kearney & Trecker Corp. respectively, a Dutch lunch with special entertainment features provided by the Section, and winding up with a Production Dinner on May 8.

Harry L. Horning, Past-President of the Society, is to be toastmaster at the dinner, which is all that needs to be said to assure members that it will be an enjoyable affair. It is also to be informative and pertinent, because Dr. E. A. Ross, of the University of Wisconsin, is going to talk about economical production under present conditions.

The program for the session on the first afternoon was arranged by the Meetings Committee of the Production Activity Committee of the Society.

The two technical sessions on the second day and the dinner in the evening were arranged by Chairman J. R. Frantz and members of the Milwaukee Section. Eugene Bouton, supervisor of time-study of the J. I. Case Co., is to be chairman of the forenoon technical session on the second day, and J. B. Armitage, chief mechanical engineer of the Kearney & Trecker Corp., will be chairman of the afternoon session.

Stanley Hale Bullard

AS THE RESULT of an attack of heart trouble nearly a year ago, Stanley Hale Bullard, vice-president of the Bullard Co., of Bridgeport, Conn., passed away at his home in Fairfield, Conn., March 23.

Mr. Bullard was a prominent figure in the machine-tool industry and in National engineering and manufacturing circles. He at various times held the following offices: director of the Chamber of Commerce of the United States; first president of the National Association of State Chamber of Commerce Officials; president for four years of the Connecticut Chamber of Commerce;

vice-president of the Atlantic Deeper Water Ways Association; member of the New England Shippers Advisory Board of the American Railway Association; vice-president of the Bridgeport Manufacturers Association; vice-president of the Bridgeport Chamber of Commerce; member of the Connecticut division of the New England Governors Railway Advisory Commission; member of the American Society of Mechanical Engineers, the Society of Automotive Engineers, the Machine Tool Builders Association, the Engineers Club of New York, the Bridgeport Engineering Institute, and the Board of Education of Fairfield, Conn.

In December, 1922, Mr. Bullard was

admitted to the Society of Automotive Engineers with the grade of Member.

Mr. Bullard was born at Hoboken, N. J., on July 4, 1877, and was the son of E. Payson Bullard, founder of the machine-tool company of which the son became vice-president after having started in the business as an apprentice and worked his way up. He was graduated from the New York Military Academy in 1890, and after serving his apprenticeship, joined the sales force of the Bullard company and managed an exhibit of its products at the Pan-American Exposition in Buffalo in 1901. Four years later he was made general sales manager, and in 1906 became vice-president.

Personal Notes of the Members

Williams, Moskovics and Herrington in New Company

Incorporation papers were filed in Indiana in March for the Marmon-Herrington Co., Inc., for the manufacture of multiple-drive motor-trucks of a very specialized type. The new company is a subsidiary of the Marmon Motor Car Co., of Indianapolis, and is to start operations at once in a part of the Marmon plant in that city.

G. M. Williams, president of the Marmon Motor Car Co., is president of the new company and A. W. Herrington, consulting engineer, of the City of Washington, is vice-president and chief engineer. F. E. Moskovics, formerly president of the Stutz Motor Car Co., and more recently president of the Improved Products Corp., of New York City, is chairman of the board of directors. The new truck is to be built from designs perfected by Mr. Herrington, who has had a long experience in the operation of motor transport in the Army and in design-



G. M. WILLIAMS

ing military and commercial motor-vehicles for the most severe operating conditions.

Mr. Williams became a member of the Society in June, 1921, at which time he was general manager of the Dayton-Wright Co., of Dayton, Ohio. He was also a member of the Dayton Engineers Club. Born at Nanaimo, British Columbia, in 1889, he studied at Trinity College and then took a special course in engineering mathematics at the Soo Technical Institute at Sault Ste. Marie, Ontario, in 1908 and 1909. His professional activities

began in 1906, with Thomas Byrne, civil engineer, in Sault Ste. Marie. For 10 years thereafter he was engaged in hydroelectric powerplant engineering design and installation work in Canada, successively with Mr. Byrne and the Lake Superior Power Co., in Sault Ste. Marie; and the H. E. Talbott Co., of Dayton, Ohio.

From 1914 to 1916, Mr. Williams was assistant vice-president of the Dayton Metal Products Co., for which he had charge of engineering, inspection and manufacturers' relations with purchasers. His next change brought him into the aeronautic field, as general superintendent of the Dayton-Wright Airplane Co. By 1919 he had become general manager of the company, a position he retained until 1924, when he was elected president and general manager of the Wire Wheel Corp. of America, in Buffalo. His connection with the Nordyke & Marmon Co. began in 1925, as president and general manager. The company changed its name to the Marmon Motor Car Co. in that year and Mr. Williams has retained the presidency and general manager-ship to the present time.

Mr. Moskovics has been a member of the Society for 23 years and has been an enthusiastic and active worker in the organization, having served as a Councilor, a member of the National Meetings and Simplified Practice Committees, and Chairman of the House Committee, Constitution Committee and Reorganization Committee. He has presented a number of papers before the Society and was a member of the Indiana Section for many years.

Mr. Moskovics has had a notable career in the industry. He was born in Hungary but came to America in his early childhood and, after studying engineering at the Armour Institute of Technology in Chicago and also in Europe, he entered the automobile industry with the Daimler company in Europe. In this Country he was successively connected with the Continental Tire Co., Brandenburg Brothers, the Frayer-Miller Motor Co., the Kingston Motor Car Co., the Bristol Engineering Corp., the Remy Electric Co., the Nordyke & Marmon Co., of which he became vice-president; the Franklin Automobile Co., also as vice-president, and, in 1925, president of the Stutz Motor Car Co. He resigned the last position in 1929 and the following year was elected president of the Improved Products Corp.

Mr. Herrington also has had a noteworthy career in the automobile industry. He is the son of Mr. Arthur Herrington, the well-known architect

of Madison, N. J., and was educated in the public schools of that place and at the Stevens Institute of Technology in Hoboken, N. J.

After serving an apprenticeship as a machine hand and at other activities in the industry, he joined the engineering department of the Harley-Davidson Motor Co. and became assistant to the chief engineer.

The World War brought Mr. Herrington into the United States Army on Oct. 15, 1917, with a commission as first lieutenant and appointment as



F. E. MOSKOVICS

consulting engineer on design of standardized motorcycles in the engineering department of the motorcycle section of the Quartermaster Corps. In 1918 he was promoted to captain and ordered to the A.E.F. in France, where he served with the chief Motor Transport officer under the G-4 Section of the First Army.

The following year he returned to the Harley-Davidson company, and in 1920 was made assistant chief engineer of the company. Two years later he returned to the Army as chief engineer of the engineering and design section of the Motor Transport Division of the Quartermaster Corps at Camp Holabird, a position that he retained until 1925. The succeeding three years he devoted to consulting engineering work in the City of Washington. During 1929 and 1930 he served the Coleman Motor Corp., of Washington, in the capacity of general manager.

Mr. Herrington's extensive experience in the motorcycle and motor-transport fields and his great energy

resulted in his appointment in 1918 as a member of the Motorcycle Division of the Standards Committee of the Society, on which he served for the following five years, and to the Motor-Truck Division in 1923. He has served on various Committees as follows:

Chairman, Motorcycle Division, Standards Committee, in 1925; member, Sections Committee, 1924, 1926



A. W. HERRINGTON

and 1927; member, Motor-Truck Division, 1923, 1924, 1925, 1928 and 1929; Vice-Chairman, Motor-Truck Division, 1926; member, Meetings Committee, 1925, 1926 and 1928; member, Research Committee, 1927 and 1928; member, Ordnance Advisory Committee, 1928 to 1931; member, Stock-Car Contest Advisory Committee, 1928 to 1931; member, Operation and Maintenance Committee, 1927 and 1930; member, Motor-Truck and Motorcoach Committees, 1930. Last year he was elected a Councilor of the Society.

Few men have filled so many committee appointments in the Society in a period of a dozen years or rendered such active service for the good of the organization. Two papers presented by Mr. Herrington before the Society have been published as follows: Motor Transportation as a Passenger-Carrying Agency, *THE JOURNAL*, August, 1925, p. 157, and Using Truck-Operating Costs To Increase Delivery Efficiency, *THE JOURNAL*, November, 1927, p. 535.

Chamberlin Organizes Flying Service

Application papers were filed in Trenton, N. J., in April for the incorporation of the Chamberlin Flying Service, Inc., of which Clarence D. Chamberlin is president and sole owner. The new company was or-

ganized as a sales and service corporation for the Chamberlin airplanes now being manufactured at a plant operated by Mr. Chamberlin at the Jersey City Airport. The new corporation plans to operate a general flying service, carry air express, charter planes for special flights, give flying instructions, and conduct aerial photography, and, in addition, offer a consulting service for airports, schools, airlines and airplane manufacturers.

Mr. Chamberlin became a member of the Society in 1930. He was born at Denison, Iowa, and after attending the public school and a business college there, studied electrical engineering at Iowa State College in Ames. For three years from 1914 to 1917, he owned an automobile agency. Since 1919 he has been engaged in airplane manufacturing, for 10 years as owner of the Chamberlin Aeronautical Co. and during 1928 and 1929 as president of the Crescent Aircraft Corp. World fame came to Mr. Chamberlin with his successful transatlantic flight with Charles Levine from New York City to Eisleben, Germany, in June, 1927, when they covered a non-stop flight of 3911 miles in 42½ hr.

Pitcairn Awarded Collier Trophy

To Harold F. Pitcairn and his associates of the Pitcairn-Cierva Autogiro Co. of America, of Philadelphia, has been awarded the Collier Trophy for the year 1930 for their development and application of the Cierva Autogiro. The announcement of the award was made early in April by the Hon. Hiram Bingham, United States senator from Connecticut and president of the National Aeronautic Association. The trophy is awarded annually by the association for "the greatest achievement in aviation in America, the value of which has been demonstrated during the preceding year." It is expected that the formal presentation of the award to Mr. Pitcairn and his associates will be made by President Hoover in the near future.

The Collier Trophy was offered by the late Robert J. Collier and was first awarded in 1911 to Glenn H. Curtiss for development and demonstration of the hydro-airplane. In 1913 it was awarded to Orville Wright for development and demonstration of the stabilizer. In 1927 it was awarded to Charles L. Lawrance for development of the radial air-cooled aeronautic engine; in 1928 to the Aeronautics Branch of the Department of Commerce for the development of airways and air navigation facilities; and in 1929 to the National Advisory Committee for Aeronautics for the development of efficient cowling for radial air-cooled engines.

The award for 1930, recently announced, was unanimously recommended by a special committee appointed by

Senator Bingham which met in the City of Washington last February to make its recommendation. The members of the Committee are: Major Walter G. Kilner, of the Army Air Corps, chairman; Porter Adams, chairman of the executive committee of the National Aeronautic Association; Capt. Emory S. Land, U.S.N.; Dr. A. F. Zahn, chief of the division of aeronautics of the Library of Congress; and Gilbert G. Budwig, director of air regulation, Aeronautics Branch of the Department of Commerce.

Mr. Pitcairn was elected to Associate Member grade in the Society in April, 1926, at which time he was owner of Pitcairn Aviation, in Philadelphia, which owned a flying-field in Pennsylvania and was engaged in commercial aviation. He was also directing the designing and construction of airplanes and engines, employing a staff of about 30 men in various technical lines, and was president of the Aero Club of Pennsylvania. He was born at Bryn Athyn, Pa., in 1897.

In 1925 Mr. Pitcairn saw Juan de la Cierva, the inventor of the Autogiro, fly the machine and became so greatly interested in its possibilities that three years later he secured American rights to build the machines. Since then he has devoted his factory near Philadelphia to continuously developing the design for greater efficiency and safe-



HAROLD F. PITCAIRN

ty. Through his good offices, the Society was enabled to secure Mr. Cierva as a speaker at the dinner session of the Aeronautic Meeting in Cleveland in August, 1929. Mr. Cierva's paper on the Autogiro, which was the first complete technical description of the principles of the machine published in America, was printed in the *S.A.E. JOURNAL* for September, 1929, p. 204. A more recent paper, in which the

principles were fully analyzed, was given by W. Lawrence LePage, of the Kellett Aircraft Corp., at the Metropolitan Aeronautic Meeting in May, 1930, and published in the S.A.E. JOURNAL for September, 1930, p. 257.

Welsh Heads a Traffic Consultant Organization

James W. Welsh, a traffic-engineering consultant who went to Cleveland in 1929 to be assistant to the president of the Cleveland Railway Co., resigned that position on March 31 to establish his own organization of traffic consultants. He has opened headquarters in this field of engineering in the Equitable Building in New York City and also maintains an office in Cleveland.

Mr. Welsh went to Cleveland as a nationally recognized authority on electrical engineering and traffic. He had been for seven years the executive secretary of the American Electric Railway Association and had devoted much study to proposed coordination of rapid-transit and surface railways and the traffic problem in large cities.

Born in Springfield, Ohio, Mr. Welsh received his technical education in Wittenberg College, Harvard University and the Massachusetts Institute of Technology. From 1906 to 1917 he was affiliated with the Pittsburgh Railways; during the World War he was transportation engineer of the Emergency Fleet Corp.; and later became secretary of the American Electric Railway Association. In 1924 he was a member of the special committee that studied transportation conditions in Europe for the operators of American electric railways.

Mr. Welsh was elected a member of the Society in 1923.

W. W. Nichols Decorated

The Order of the White Lion was conferred upon W. W. Nichols and Prof. F. G. Novy by the Czechoslovak Government at a reception by the American National Alliance of Czechoslovaks given in their honor at the Hotel Statler in Detroit on April 13. They were decorated with the order by Dr. Ferdinand Veverka, the Czechoslovak minister to the United States.

Mr. Nichols is vice-president and mechanical engineer of D. P. Brown & Co., of Detroit, and has been a member of the Society since 1920. He was born in Brooklyn, N. Y., and joined D. P. Brown & Co. in 1909, as mechanical engineer in charge of power-transmission and conveying-machinery design and sales. For 20 years prior thereto he had served a number of industrial companies in various capacities, most of the time in Philadelphia. From 1887 to 1891 he was first apprentice and later assistant foreman with William Sellers & Co., of that city, and

again was with that company in 1906 and 1907 as superintendent of the power-transmission department. From 1891 to 1897 he was foreman and works manager for Accles, Ltd., of Birmingham, England, bicycle and internal-combustion engine manufacturers. The succeeding four years he was in charge of sales and purchase of machine-tools for P. & W. Maclellan, Ltd., of Glasgow, Scotland. Returning to the United States in 1901, he served for two years as superintendent of the Tabor Mfg. Co., of Philadelphia, and then as machinery salesman successively for six years for W. S. Shipley, the Diamond Drill & Machine Co. and the Van Dyke, Churchill Co.

Mr. Nichols was vice-president in



W. W. NICHOLS

charge of promotion of the Society of Industrial Engineers from 1923 to 1925 and has presented papers on power transmission subjects before the S.A.E., the National Safety Council, the American Pulp and Paper Mill Superintendents Association and the International Management Congress at Prague, Czechoslovakia. The paper presented before the S.A.E. was entitled, Power-Transmission Engineering as an Economy, and was published in the S.A.E. JOURNAL for December, 1928, p. 557. The paper before the International Management Congress was on Belting—Purchases, Maintenance, Power and Methods of Obtaining Complete Data on Its Performance.

Since his election to membership, Mr. Nichols has also been a member of the Detroit Section and since 1929 has been a member of the Production Committee of the Society.

Harold E. Anderson is now employed in the experimental department of the Oakland Motor Car Co., of Pontiac, Mich. He previously served the Studebaker Corp. of America at South Bend,

Ind., as a member of its commercial-car engineering department.

Ralph F. Anderson is now employed by the R. I. Raymond Co., of Chicago, as a sales engineer.

Thomas Backus, designer, is now serving the Brown-Lipe Division of the Spicer Mfg. Corp., of Toledo, Ohio. He previously was employed as designing engineer on transmissions and clutches by the Fuller & Sons Mfg. Co., a division of the Unit Corp., of Milwaukee.

Walter E. Battles has been promoted from the position of mechanical draftsman to the post of engineer with the Pfaunder Co., of Rochester, N. Y.

Oscar C. Bornholt was recently elected vice-president of the Fulton Co., of Milwaukee. Before assuming the duties of his new position he was employed by the Houdaille-Hershey Corp., of Chicago, as a research engineer.

Capt. M. V. Brunson, of the Quartermaster Corps (motors), United States Army, recently returned from command of the Atlantic Motor Transport Pool at Fort Davis, Panama Canal Zone, and has been assigned as commanding officer of the old Camp Jessup Motor Transport General Depot, Atlanta, Ga., and as Post Quartermaster at Fort McPherson, Ga.

R. W. Budd is now vice-president of the Greyhound Management Co., of New York City. He was formerly president of the Northland Greyhound Lines, Inc., of Illinois, with headquarters in Minneapolis.

Ralph C. Chesnutt, experimental engineer, recently joined the Cleveland Tractor Co., of Cleveland. He previously was employed by the Marmon Motor Car Co., of Indianapolis.

Fred Cliffe, who has been serving the Tecalemit Co., Ltd., of Brentford, Middlesex, England, has been appointed chief engineer of that company, having been promoted from the post of designer.

W. Chapin Condit is serving the Sun Oil Co., of Marcus Hook, Pa., as a research engineer. His former connection was with the Standard Oil Development Co., of Elizabeth, N. J., which he served as automotive research engineer.

Edward F. Cooke has been assigned the post of garage manager with Monarch Motors, Ltd., of Calgary, Alta., Canada, after serving the company as used-car manager for seven years.

Kenneth S. Cullom, who was previously associated with the E. W. Bliss Co., of Brooklyn, N. Y., as mechanical engineer in aircraft-engine production, is now test engineer in the aircraft-engine department of the Glenn L. Martin Co., of Baltimore.

Reuben E. Fielder, former regional sales manager, eastern territory, for

(Continued on page 44)

Applicants Qualified

ASH, CARSON W. (J) superintendent of equipment, operation and maintenance, State Road Commission of West Virginia, District No. 4, Clarksburg, W. Va.; (mail) Box 1041.

ATWOOD, SETH B. (A) partner, Atwood Vacuum Machine Co., 2500 North Main Street, Rockford, Ill.

AXTATER, CAPT. KARL S., U. S. A. (S M) chief, lighter-than-air branch, experimental engineering section, Materiel Division, Air Corps, Wright Field, Dayton, Ohio.

BAKKE, E. K. (A) president, Bakke-Daniels, Inc., Vancouver, Wash.; (mail) 2704 F Street.

BARDWELL, HAROLD F. (M) research engineer, in charge of experimental laboratory, Delco Appliance Corp., Rochester, N. Y.; (mail) 79 Burlington Avenue.

BEST, ROBERT D. (M) experimental engineer, Continental Oil Co., Ponca City, Okla.

BOWLES, PERCY GEORGE (M) factory superintendent, Willys-Overland, Ltd., Toronto, Ont., Canada; (mail) 3 Grattan Street, Weston, Ont., Canada.

BOWMAN, LLOYD R. (J) draftsman, experimental engineering department, International Harvester Co., Fort Wayne, Ind.; (mail) 2130 La Fayette Street.

BRADER, JOHN HARRY (J) assistant engineer, designing and construction, Jacob Press' Sons, 501 West 33rd Street, Chicago.

BRUCE, ROBERT ARTHUR (F M) managing director, Westland Aircraft Works, Yeovil, England.

CHERON, PIERRE J. (A) art director, Moto-Meter Gauge & Equipment Corp., Toledo; (mail) 65 Locust Street, Stratford, Conn.

DALE, FRANK L. (A) general sales manager, National Oil & Supply Co., 179 Frelinghuysen Avenue, Newark, N. J.

DELANEY, GEORGE B. (A) service representative, General Motors Truck Co., Rapid Street plant, Pontiac, Mich.

DEPUE, ROBERT N. (A) vice-president, treasurer, general manager, Essex Sales Co., 234 Central Avenue, Newark, N. J.

DIETER, WILLIAM LOUIS (J) aeronautical engineer, Sikorsky Aviation Corp., Stratford, Conn.; (mail) 27 Park Circle, Milford, Conn.

DUBROW, CHARLES W. (J) automobile design, student of machine design, drafting, Wiggins Trade School, Los Angeles; (mail) 1002 South Burnside Street.

DUMSER, LEO A. (M) chief engineer, Sundstrand Machine Tool Co., Rockford, Ill.; (mail) 516 North Prospect Street.

EARHART, ALBERT (A) supervisor of service and maintenance of Marmon cars, Marmon Sales, Inc., 1200 Broadway, Denver.

EBBERS, HAROLD L. (J) sales engineer, Michigan, Ohio and Indiana, Newton Die Casting Corp., New Haven, Conn.; (mail) 1607 Howard Street, Detroit.

FICKETT, CALVIN L. (A) superintendent, automotive department, Southworth Machine Co., Portland, Me.; (mail) 546 Ocean Avenue.

GOODHALL, ARTHUR RAYMOND (J) designer, Hudson Motor Car Co., 12601 East Jefferson Avenue, Detroit.

HANSEN, AUGIE L. (M) president, general manager, in charge of engineering, A. L. Hansen Mfg. Co., 5037 Ravenswood Avenue, Chicago.

HANSEN, CLAUDE S. (J) sales engineer, Fuller & Johnson Mfg. Co., Madison, Wis.; (mail) 853 East Johnson Street.

HARDY, EVAN A. (M) professor of agricultural engineering, University of Saskatchewan, Saskatoon, Sask., Canada.

HARPHAM, HORACE (A) partner, Harpham Brothers, 129 Jarvis Street, Toronto, Ont., Canada.

HULL, GEORGE E. (A) vice-president, general manager, Parks & Hull, Inc., 1031 Cathedral Street, Baltimore.

The following applicants have qualified for admission to the Society between March 10 and April 10, 1931. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

HUXTABLE, LEONARD L. (J) research engineer, Martin Motors, Inc., East Rutherford, N. J.; (mail) 2709 Heath Avenue, New York City.

IAVELLI, TENO (J) layout man, Timken-Detroit Axle Co., Detroit; (mail) 1566 Ferdinand Avenue.

JACKSON, A. VERNE (M) district salesman, Buda Co., Harvey, Ill.; (mail) 1349 Virginia Park, Detroit.

JENNINGS, BRENTON WILLIAM (A) lubrication engineer, Utah Oil Refining Co., 700 Newhouse Building, Salt Lake City, Utah.

JEWETT, DANIEL G. (A) superintendent of maintenance, L. Bamberger & Co., Newark, N. J.; (mail) 15 University Court, South Orange, N. J.

JONES, OSCAR BERNARD (M) president, Detroit College of Applied Science, 8203 Woodward Avenue, Detroit.

KAHLENBERG, ROGER W. (M) engineer, Kahlenberg Brothers Co., Two Rivers, Wis.; (mail) 2611 West Street.

KARNS, C. B. (M) manager, manufacturing plants, Standard Oil Co. of Pennsylvania, Pittsburgh; (mail) 916 Wellesley Road, East End.

KASS, CHARLES B. (J) mechanical engineer, Standard Oil Development Co., Elizabeth, N. J.; (mail) 340 Verona Avenue.

KIMBALL, W. S. (A) president, manager, Pittsburgh Auto Spring Co., 5900 Centre Avenue, Pittsburgh.

KLEIN, JOHN M. (M) chief chemist, American Oil Co., Baltimore; (mail) 200 North Linwood Avenue.

KOERNER, THEODORE W. (M) mechanical assistant to president, Gemmer Mfg. Co., Detroit; (mail) 749 Pallister Avenue.

LEA, SNOWDEN E. (A) foreman, Keystone Aircraft Corp., Bristol, Pa.; (mail) 213 East Front Street, Trenton, N. J.

LEAHEY, JOHN ARTHUR (A) owner, Leahey-Marmon Co.; general manager, Cape May Chemical Co.; half owner, Scull-Leahey Co., Tuckahoe, N. J.; (mail) Tuckahoe, N. J.

LIGNIAN, J. A. (J) foreman, Flint experimental department, Chevrolet Motor Co. of Michigan, Flint, Mich.; (mail) 2209 Detroit Street.

LONGSTAFF, G. E. (F M) production engineer, Rover Motor Co., Ltd., Tyseley, Birmingham, England; (mail) Rushley Road, Dore North, Sheffield, England.

MADGET, CHARLES CHESTER (A) service manager, Reo Motor Sales Co. of Toronto, Ltd., 1029-1047 Bay Street, Toronto, Ont., Canada.

MALLETT, LLOYD ALFRED (J) assistant to chief engineer, Kenworth Motor Truck Corp., Seattle; (mail) 652 East 73rd Street.

MARSHALL, A. G. (M) technical adviser, Shell Oil Co., Martinez, Calif.; (mail) 1600 Escobar Street.

MARTIN, GEORGE B. (J) engineer, production development department, Budd Wheel Co., Detroit; (mail) 1981 West Six Mile Road.

MEATZ, BRITTON (A) assistant foreman, Cadillac Motor Car Co., Detroit; (mail) 3385 Richton Street.

MOLLINGER, ALEXANDER J. (F M) lecturer on internal-combustion engines, Technical University of Delft, Delft, Holland; (mail) Cornelis Trompstraat 77.

ONGARO, THEODORE (A) owner, manager, Teddy's Auto Service Station, Rear 395 East Broad Street, Columbus, Ohio.

PERRY, FOSTER N. (A) manager, manufacturers sales, eastern district, United American Bosch Corp., Springfield, Mass.; (mail) 82 Marsden Street.

PHILLIPS, H. P. (A) president, superintendent of shop, Climax Jones & Quinn, 3124 Locust Street, St. Louis.

RHODES, WALTER P. (M) head of motor mechanics department, Calgary School Board, Technical High School, Calgary, Alta., Canada.

ROBIE, CHARLES F. (J) student, master pilot course, Boeing School of Aeronautics, Oakland, Calif.; (mail) 2833 Santa Clara Avenue, Alameda, Calif.

ROBINSON, WARD M. (M) chief engineer, in charge of equipment and production design, building and machine construction and maintenance, Mueller Brass Co., Port Huron, Mich.; (mail) 1408 Jenks Street.

ROZMAN, FRANK (A) body draftsman, Fisher Body Corp., Detroit; (mail) 14698 Fordham Road.

RUSSELL, JOSEPH F. (M) foundry superintendent, Aluminum Co. of America, 3110 Adeline Street, Oakland, Calif.

RUTENBER, E. R. (M) research engineer, Waukesha Motor Co., Waukesha, Wis.; (mail) 428 Washington Circle, Wauwatosa, Wis.

SCLATER, ROBERT STEVEN (J) laboratory assistant, Texas Co., Bayonne, N. J.; (mail) 418 Union Street, Jersey City, N. J.

SHAFFNER, W. L. (A) sales promotion manager, General Motors Electric Sales Corp., 12-261 General Motors Building, Detroit.

SHEELEY, C. FRANK (A) chief tool designer, Hyatt Roller Bearing Co., Harrison, N. J.; (mail) 21 Linden Avenue, Belleville, N. J.

SMYTH, A. R. (A) sales department, Imperial Oil Ltd., Regina, Sask., Canada; (mail) 3079 Rae Street.

SPALDING, F. (J) time-study engineer, J. I. Case Co., Rockford, Ill.; (mail) Byron, Ill.

STIDHAM, JAMES (A) superintendent, gas-car equipment, City Baking Co., 310 North Gay Street, Baltimore; (mail) 2654 Huntington Avenue.

SWIFT & Co. (Aff.) Union Stock Yard, Chicago; Representative: Lager, Eric W., manager, automobile department.

THOMAS, RAY J. (M) layout man, Chevrolet Motor Co., Detroit; (mail) 12338 Glenfield Avenue.

TYLER, JOHN M. (J) engineer, General Motors Research Corp., 9-228 General Motors Research Building, Detroit.

URFER, ADOLF (M) chief experimental engineer, Pioneer Instrument Co., Brooklyn, N. Y.; (mail) 8660 105th Street, Richmond Hill, N. Y.

VAUGHAN, WILBUR C. (J) chief engineer, tractor division, Vaughan Motor Works, Inc., Portland, Ore.; (mail) 1189 East Pine Street.

WALLER, D. D. (J) designer, assistant experimental engineer, A. C. Spark Plug Co., Flint, Mich.; (mail) 2044 Monteith Street.

WELLS, T. A. (J) project engineer, Curtiss-Wright Airplane Co., Wichita, Kans.; (mail) 4024 East Elm Street.

WILDMAN, CHARLES A. (M) Diesel-engine design and experimental testing, 739 East Market Street, Warren, Ohio.

WILLIAMSON, GEORGE (A) manager, director, Hay Motor & Engineering, Proprietary, Ltd., Box 55, Hay, New South Wales, Australia.

WILSON, E. A. (A) president, Ingersoll Machine & Tool Co., Ltd.; vice-president, John Morrow Screw & Nut Co., Ltd., Toronto, Ont., Canada; (mail) Ingersoll Machine & Tool Co., Ltd.

YOUNG, ROBERT D. (J) junior research engineer, Sinclair Refining Co., East Chicago, Ind.; (mail) 831 Fields Avenue, Hammond, Ind.

Applicants for Membership

ALFERT, JOHN M., service representative, Chevrolet Motor Co., *Detroit*.

ALLEN, FRANK C., shop superintendent, International Harvester Co., *Portland, Ore.*

ANDERSEN, LLOYD C., service manager, Columbia Chevrolet Co., *Vancouver, Wash.*

ARTHUR, WILLIAM E., president, National Airport Engineering Co., Ltd., *Los Angeles*.

BATT, FRED C., assistant service manager, Boulevard Garage Co., *Albany, N. Y.*

BARNES, LAWRENCE TAYLOR, technical correspondent, General Motors Products of Canada, Ltd., *Regina, Sask., Canada*.

BECHERER, V. J., manager and owner, Revere Transportation Co., *St. Louis*.

BURR, REGINALD GEDDES, western editor, *Bus Transportation*, McGraw-Hill Publishing Co., *Chicago*.

CARR, EARL M., superintendent of maintenance, Consolidated Coach Corp., *Lexington, Ky.*

CARTWRIGHT, C. M., chief mechanical superintendent, United States Bureau of Public Roads, *Portland, Ore.*

CLABAUGH, ELMER E., superintendent of automotive equipment, Lincoln Park Commissioners, *Chicago*.

CLARKE, HENRY B., president, Viscosity Engineering Corp., *New York City*.

CRIDLAND, GEORGE ERNEST, manager, Roy Howard, Ltd., *Vancouver, B. C., Canada*.

CURRIER, CHARLES E., draftsman, Chevrolet Motor Co., *Detroit*.

DALLAS, ALLEN W., structural engineer, Verville Aircraft Co., *Detroit*.

DAVISON, F. TRUBEE, Assistant Secretary of War for Aeronautics, United States Navy, *City of Washington*.

DELLINGER, WILLIAM, JR., fleet maintenance mechanic, Peck & Hill's Furniture Co., *Jersey City, N. J.*

DIETZ, CONRAD G., vice-president and general manager, Aeronautical Corp. of America, *Cincinnati*.

DUNHAM, HERBERT WARREN, service manager, Barzee Equipment Co., Inc., *Syracuse, N. Y.*

DUNLAP, KENNETH E., field engineer, Cleveland Universal Jig Co., *Cleveland*.

ELDRIDGE, JAMES A., automotive equipment inspector, Pennsylvania Electric Co., *Johnstown, Pa.*

ESSELBURNE, PETER, assistant to experimental engineer, Timken Roller Bearing Co., *Canton, Ohio*.

EVANS, JOHN MANDERSON, manager, sales engineering and development, Associated Oil Co., *San Francisco*.

FREEDMAN, ISIAHA, mechanic, Central Motors, *Sioux Lookout, Ont., Canada*.

GARRETT, HUGH C., sales representative, Vacuum Oil Co., *Kansas City, Mo.*

GOULD, GEORGE CHARLES, representative, British Tyre Service (Bristol), Ltd., Whiteladies Road, *Bristol, England*.

GREEN, RAYMOND A., chief engineer, Western Automatic Machine Screw Co., *Elyria, Ohio*.

The applications for membership received between March 16 and April 16, 1931, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

HAMMARSKJOLD, CARL GUSTAF, research engineer, A. B. Volvo, *Gothenburg, Sweden*.

HARDIN, R. F., general shop foreman, City Ice Co., *Kansas City, Mo.*

HEGEMAN, BRUCE, mechanical engineer, The Texas Co., *Bayonne, N. J.*

HOLLISTER, ARTHUR S., service manager, Donner Auto Sales Co., *Far Rockaway, Long Island, N. Y.*

HOUDIN, CHARLES, general manager of production, Société Anonyme André Citroën, *Paris, France*.

KELLOGG, HUDSON W., laboratory manager, Ethyl Gasoline Corp., *Detroit*.

KINNER, J. G., motor-truck service manager, International Harvester Co. of America, *Chicago*.

KLEISINGER, DR. EMIL, general manager, Richard Weber & Co., *Berlin, Germany*.

KUSTER, W. H., research engineer, Shaw Palmer Bakewell Co., *Los Angeles*.

LAMB, HAROLD THOMAS, technical engineer, free wheels, W. J. Armstrong Whitworth & Co., *Newcastle-on-Tyne, England*.

LANG, C. E., traffic department, traffic promotion, Blue Ridge Lines, *Pittsburgh*.

LELAND, DOUGLAS G., aviation machinist's mate, United States Navy, c/o Postmaster, *New York City*.

LUDLOW, EDMUND, assistant to chief engineer, Noblitt Sparks Industries, Inc., *Indianapolis*.

LYBECK, ROBERT F., manager, wholesale sales (chemical engineer), Colonial Beacon Oil Co., Inc., *Boston*.

MASSA, VICTOR FRANKLIN, research work, Standard Oil Development Co., *Bayway, N. J.*

MATHEWS, HARRY O., superintendent of motor equipment, Illinois Bell Telephone Co., *Chicago*.

MCELHOSE, LESTER G., test engineer, A. C. Spark Plug Co., *Flint, Mich.*

McKILLEN, J. G., JR., chief engineer, National Bronze & Aluminum Foundry Co., *Cleveland*.

MURDIE, J. A., shop superintendent, Eastern Greyhound Lines, *Syracuse, N. Y.*

MURPHY, H. M., sales manager, truck division, Walsh Motors, Inc., *Kansas City, Mo.*

NESS, HAROLD J., 2 Bremond Street, *Belleville, N. J.*

OHLER, G. H., garage foreman, Frye & Co., *Seattle, Wash.*

PAPWORTH, EDWIN F., general manager, Brown-Lipe-Chapin Division, General Motors Corp., *Syracuse, N. Y.*

PHALON, EDMOND H., manager of service distribution, Borden's Farm Products Co. of Illinois, *Chicago*.

POYER, GUY R., president and chief engineer, Poyer Aircraft Engine Co., Fairfax Airport, *Kansas City, Mo.*

PRICE, THOMAS LAWRENCE, superintendent of automotive equipment, Baltimore Transfer Co., *Baltimore*.

PRUYN, W. VAN NESS, sales engineer and supervisor of bearing sales, The Pruyn Co., *Philadelphia*.

REED, JOHN W., assistant engineer, Marmon-Herrington Co., *Indianapolis*.

REYNER, FRED P., checker and mathematician, Curtiss Aeroplane & Motor Co., Inc., *Buffalo*.

ROBILLARD, FRED S., Captain, United States Marine Corps, *Philadelphia*.

SANBORN, ELMER EDWARD, fuel engineer, Vacuum Oil Co., *New York City*.

SAYER, H. BARTLETT, Oregon district manager, The Pennzoil Co., *Portland, Ore.*

SHANAHAN, LEONARD J., president and treasurer, Standard Rim & Wheel Co., *Boston*.

SINGER, F. O., vice-president, general manager, Chicago Governor & Mfg. Co., *Chicago*.

SORIA, GUIDO, central director, Fiat Co., *Turin, Italy*.

STANSFIELD, RICHARD, research engineer, Anglo-Persian Oil Co., *London, England*.

ST. JOHN, LLOYD W., tire salesman, James T. Hawkins, *Los Angeles*.

STUMP, ROBIN D., clerk, engineering studies, Illinois Bell Telephone Co., *Chicago*.

THAYER, BYRON C., draftsman, Curtiss-Wright Airplane Co., *Wichita, Kan.*

THOMPSON, DAVID W., cost-reduction engineer, Western Electric Co., *Chicago*.

THURMAN, WILLIAM J., district service manager, The White Co., *Kansas City, Mo.*

TREFFZ, EUGENE C., president, Electrical Magneto Service Co., *Kansas City, Mo.*

VIVIAN, WILL, proprietor, Vivian Gas Engine Works, *Vancouver, B. C., Canada*.

WAITE, W. D., manager, manufacturers' sales, Dominion Rubber Co., Ltd., *Kitchener, Ont., Canada*.

WEGFORTH, JOHN FRED, Lieutenant, United States Navy, c/o Postmaster, *New York City*.

WHITTAKER, CHARLES BRITTON, field service representative, General Motors South African, Ltd., *Port Elizabeth, South Africa*.

WOOTEN, WESLEY M., product research and service testing, Standard Oil Co. of California, *San Francisco*.

YOUNGER, JOHN E., professor of mechanical engineering, University of California, *Berkeley, Calif.*

ZIEGENBEIN, WALTER EMIL, vice-president, Borbein Young & Co., *St. Louis*.

Notes and Reviews

AIRCRAFT

A New Chart for Estimating the Absolute Ceiling of an Airplane. By Walter S. Diehl. Report No. 368. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 7 pp., with tables and charts. [A-1]

This report, which was prepared for publication by the National Advisory Committee for Aeronautics, is concerned with the derivation of a chart for estimating the absolute ceiling of an airplane. This chart can be used in conjunction with the usual curves of power required and power available as an accurate substitute for extended calculation, or it may be used for the estimation of absolute ceiling when power curves are not available.

Maneuverability Investigation of the F6C-3 Airplane with Special Flight Instruments. By C. H. Dearborn and H. W. Kirschbaum. Report No. 369. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 18 pp., illustrated. [A-1]

The investigation herein reported was made for the purpose of obtaining information on the maneuverability of the F6C-3 fighter airplane. The tests were conducted by the National Advisory Committee for Aeronautics at Langley Field, Va., at the request of the Bureau of Aeronautics of the Navy Department. It is the first in a series of similar investigations to be conducted on the abilities of these airplanes to maneuver, and also to establish a fund of quantitative data which may be used in formulating standards of comparison for rating the maneuverability of any airplane. A large part of this initial investigation was necessarily devoted to the development and trial of methods suitable for use in subsequent investigations of this nature.

Effect of Variation of Chord and Span of Ailerons on Hinge Moments at Several Angles of Pitch. By B. H. Monish. Report No. 370. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 15 pp., with tables and charts. [A-1]

This report presents the results of an investigation of the hinge moments of ailerons of various chords and spans on two airfoils having the Clark-Y and U.S.A.-27 wing-sections, supplementing the investigations described in References 1 and 2 of the rolling and yawing moments due to similar ailerons on these two airfoil sections.

The measurements were made at va-

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

rious angles of pitch but at zero angle of roll and yaw, the wing chord being set at an angle of +40 deg. to the fuselage axis. In the case of the Clark-Y airfoil the measurements have been extended to a pitch angle of 40 deg. using ailerons of span equal to 67 per cent of the wing semispan and chord equal to 20 and 30 per cent of the wing chord.

The work was done in the 10-ft. tunnel of the Bureau of Standards on models of 60-in. span and 10-in. chord, having square tips, no taper in plan form or thickness, zero dihedral, and zero sweepback.

The Variation in Pressure in the Cabin of an Airplane in Flight. By Melvin N. Gough. Technical Note No. 368. Published by the National Advisory Committee for Aeronautics, City of Washington, March, 1931; 6 pp., 5 figs. [A-1]

The pressure in the cabin of a Fairchild cabin monoplane was surveyed in flight and was found to decrease with increased air-speed over the fuselage and to vary with the number and location of openings in the cabin. The maximum depression of 2.2 in. of water (equivalent pressure altitude at sea level of 152 ft.) occurred at the high speed of the airplane in level flight with the cabin closed. Any pressure-operated instruments installed in the cabin would be affected by this cabin-pressure depression. These tests were conducted at the Langley Memorial Aeronautical Laboratory.

The Production of Turbulence. By W. Tollmien. Translated from *Aus den Nachrichten der Gesellschaft der*

Wissenschaften zu Göttingen Mathematisch-Physikalische Klasse, 1929. Technical Memorandum No. 609; 32 pp., 5 figs. [A-1]

Optico-Photographic Measurements of Airplane Deformations. By Hans Georg Küssner. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Vol. 21, No. 17, Sept. 15, 1930, Verlag von R. Oldenbourg, München-Berlin. Technical Memorandum No. 610; 16 pp., 29 figs. [A-1]

Mechanical Similitude and Turbulence. By Th. v. Kármán. Translated from *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen*, 1930. Technical Memorandum No. 611; 19 pp., 5 figs. [A-1]

Static Longitudinal Stability of "Ente" Airplanes. By Heinrich Georg Kiel. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Dec. 15, 1930. Technical Memorandum No. 612; 27 pp., 21 figs. [A-1]

The foregoing four Technical Memoranda were issued during March by the National Advisory Committee for Aeronautics, City of Washington.

Air Flow through Exhaust Valve of Conical Seat. By Keikiti Tanaka. Report No. 67 of the Aeronautical Institute, Tokio Imperial University, January, 1931; 24 pp., with illustrations and tables. [A-1]

The paper is a continuation of the author's former research on the air-flow through a suction valve having a conical seat. In the case of a suction valve, air flows from the suction pipe into a cylinder of larger diameter. In the present case of an exhaust valve, on the contrary, air flows from the cylinder into an exhaust pipe of smaller diameter. In other words, air-flow diverges through a suction valve and converges through an exhaust valve. This difference between the two cases is remarkable and thus the valves have different flow characteristics.

The present paper deals with this case of an exhaust valve. Some remarks are also made on mathematical study.

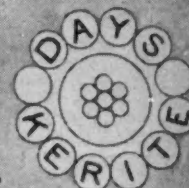
The International Wing Model Measured in the Wind-Tunnels of Japan. By the Wind-Tunnel Committee specially appointed by the Aeronautical Council of Japan. Report No. 66 of the Aeronautical Research Institute, Tokio Imperial University, December, 1930, 440 pp., profusely illustrated with diagrams and tables. [A-1] (Continued on next left-hand page)

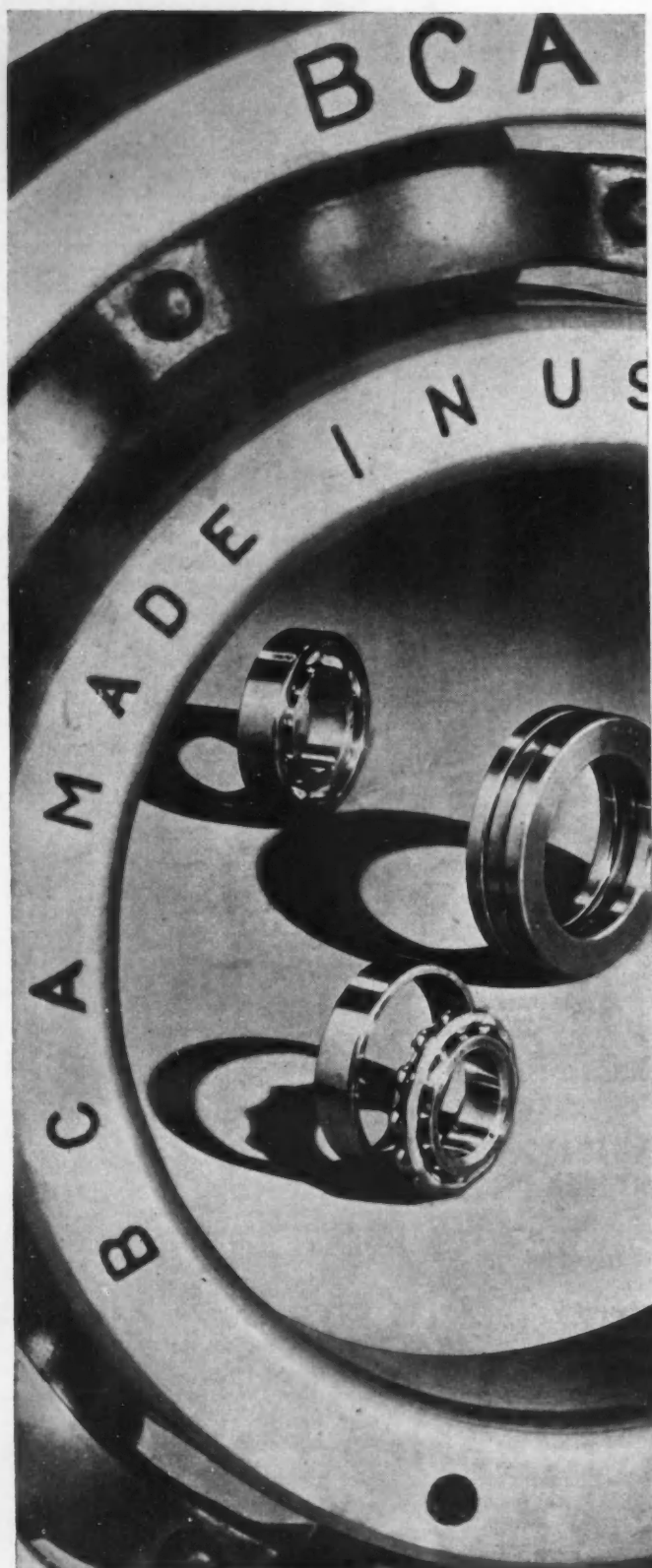


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Notes and Reviews

Continued

The present investigation is a continuation of the test of airship models in connection with the international model trials in wind-tunnels, which has been initiated at the proposal of the National Physical Laboratory, of Teddington, England. The object of the investigation is to compare the aerodynamic characteristics of a wing model measured at as many as possible of the aerodynamic laboratories of the world.

The model is described in word and picture, and the measurements carried out in Japan are given. The measurements were obtained in the following five wind-tunnels; the Aeronautical Research Laboratories, Imperial Japanese Navy; the Aeronautical Research Institute of Tokio Imperial University; the technical department of the Board of Military Air Service; the Mitsubishi Aircraft Co., Ltd.; and the Kawanishi Aircraft Co., Ltd. The results are expressed in lift, drag and moment coefficients, and the treatise is highly mathematical.

Wind-Tunnel Tests on Airplane Wheel Cowlings. By J. Le Ber. Published in *Aviation Engineering*, February, 1931, p. 18. [A-1]

The tests of this study were made to determine the effect on the drag of an airplane wheel of various streamline fairings. The results obtained indicate that in the use of wheel cowlings a distinct possibility exists of increasing the overall of an airplane, since by means of careful design the drag of the wheel alone may be reduced by some 30 per cent by the use of such fairing.

The fairings were designed in accordance with airplane practice of today. Thus, the upper surface of the wheel was covered and about 25 per cent of the tire protruded through an opening to meet conditions of landing, travel, tire flattening and the like. Photographs illustrate the general type of fairing used.

Some Aspects of the Design of Sea-Going Aircraft. By A. Gouge. Published in *Flight*, Jan. 16, 1931, p. 59. [A-1]

The character of the British Empire is such that seaplanes and flying-boats are of particular use and interest within its domain. In this interest, Mr. Gouge points out the recent developments in this field, including the Dornier Do-X and the successful British flying-boat for passenger and mail carrying, and describes in some detail the method and procedure adopted by his own firm, Short Brothers, when starting a new design of either a flying-boat or a seaplane.

The article is concluded in the Jan. 23, 1931, issue of *Flight*.

Design and Construction of Aluminum-Alloy Floats. By C. F. Nagel, Jr., and G. O. Hoglund. Published in *Aviation Engineering*, February, 1931, p. 9. [A-1]

Reliability and weight are the two things which the designer has to take into consideration when selecting materials for the construction of boat hulls, pontoons and wing-tip floats, which consist of built-up framework covered with sheet. To illustrate this, the author has pictures of the hulls of several flying-boats in various stages of construction.

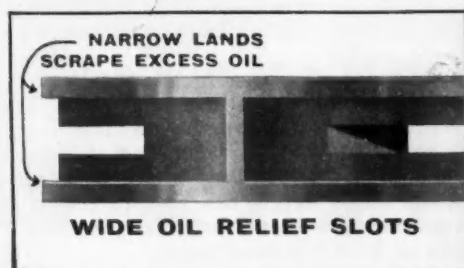
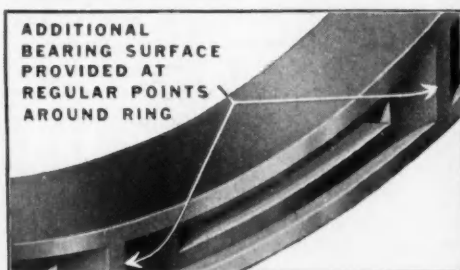
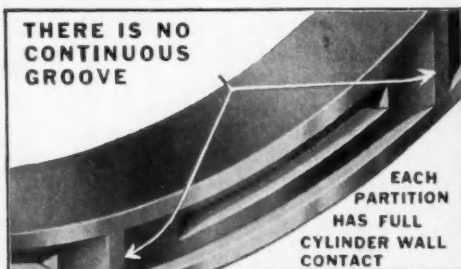
The materials generally selected for this construction are 17S Alclad, which has great corrosion resistance, and 17S, which is a strong aluminum alloy of the duralumin type that is easily formed and enduring in service when properly protected. The use of these materials minimizes the amount of heat-treating necessary in the shop.

Special precaution should be taken to make the construction watertight and easily accessible.

In general practice, aluminum alloys employed in the construction of boat hulls, pontoons and wing-tip floats are properly protected with finish when they are in danger of

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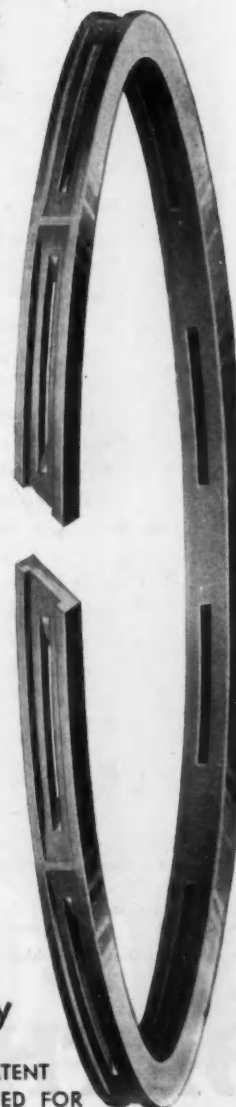
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Notes and Reviews

Continued

excessive exposure, but they have amply demonstrated their durability and reliability.

Testing Aeroplane Controls. By H. L. Stevens. Published in *The Journal of the Royal Aeronautical Society*, February, 1931, p. 96. [A-1]

The author first surveys aircraft as they exist and then considers ideal control conditions. Among the latter Mr. Stevens includes controls operated by instinctive body movements, aircraft response progressive to the control movement in all conditions of flight, independent controls, the three controls in harmony with one another, and a number of other less important generalities.

Control at the stall, spinning, and diving are discussed at length, and (a) control at the stall, including spinning; (b) fighting maneuvers; and (c) control in normal flight, are the three classifications under which the author considers the testing problem.

After a brief survey of available and practical methods and instruments of test, the following conclusions are reached:

There are three kinds of testing: research, competition, and development.

Research on controls is largely developed to the end of finding out how nearly model and full-scale airplane agree. All the properties, however, involve such a great mass of measurements that research also has to be directed to finding out how few are essential and how many can be done without.

When several aircraft to the same specification are entered in a competition, the selection of the best can be left to the opinion of expert pilots.

In development, the problem is how to improve aircraft. In competition, the best is discovered and, to perpetuate its properties in other types, it is necessary to find out why it is the best, that is, to find out what pilots do with it, what forces they use and how it responds, and then return to research to make the best airplane still better.

The Design of Wind-Tunnels. By Ernest F. Relf, A.R.C.Sc. Published in *Aircraft Engineering*, February, 1931, p. 27. [A-1]

The author reviews the history of the development of existing tunnel equipment and also the results of the intensive study of types of wind-tunnels other than the standard N.P.L. type, since this latter was entirely unsuited for the compressed-air tunnel.

The Göttingen type is a single-duct return-flow open-jet tunnel. The two main features that contribute to its success are the cascades of guide blades at the corners, which assure a uniform velocity at all points of the circuit, and the rapidly contracting nozzle at the entrance to the working section, which reduces to a very great extent the magnitude of velocity fluctuations. This type of tunnel has proved to be more economical, both in cost and maintenance.

Controllable-Pitch Propeller. By W. R. Turnbull. Published in *The Journal of the Royal Aeronautical Society*, March, 1931, p. 231. [A-1]

Mr. Turnbull treats his subject exhaustively in this brief favoring the use of the controllable-pitch propeller, which he defines as one having the blades mounted in the hub so that they can be turned about their radial axes during flight at the will of the pilot.

The author compares the performance of fixed-pitch and controllable-pitch propellers under various conditions of flight; that is, top speed, take-off, climb, high-altitude flying, best cruising speed, and also with supercharged engines, multiple power units, and with the plane heavily loaded. He concludes that, if the added weight can be kept reasonably low, the great advantages in performance resulting

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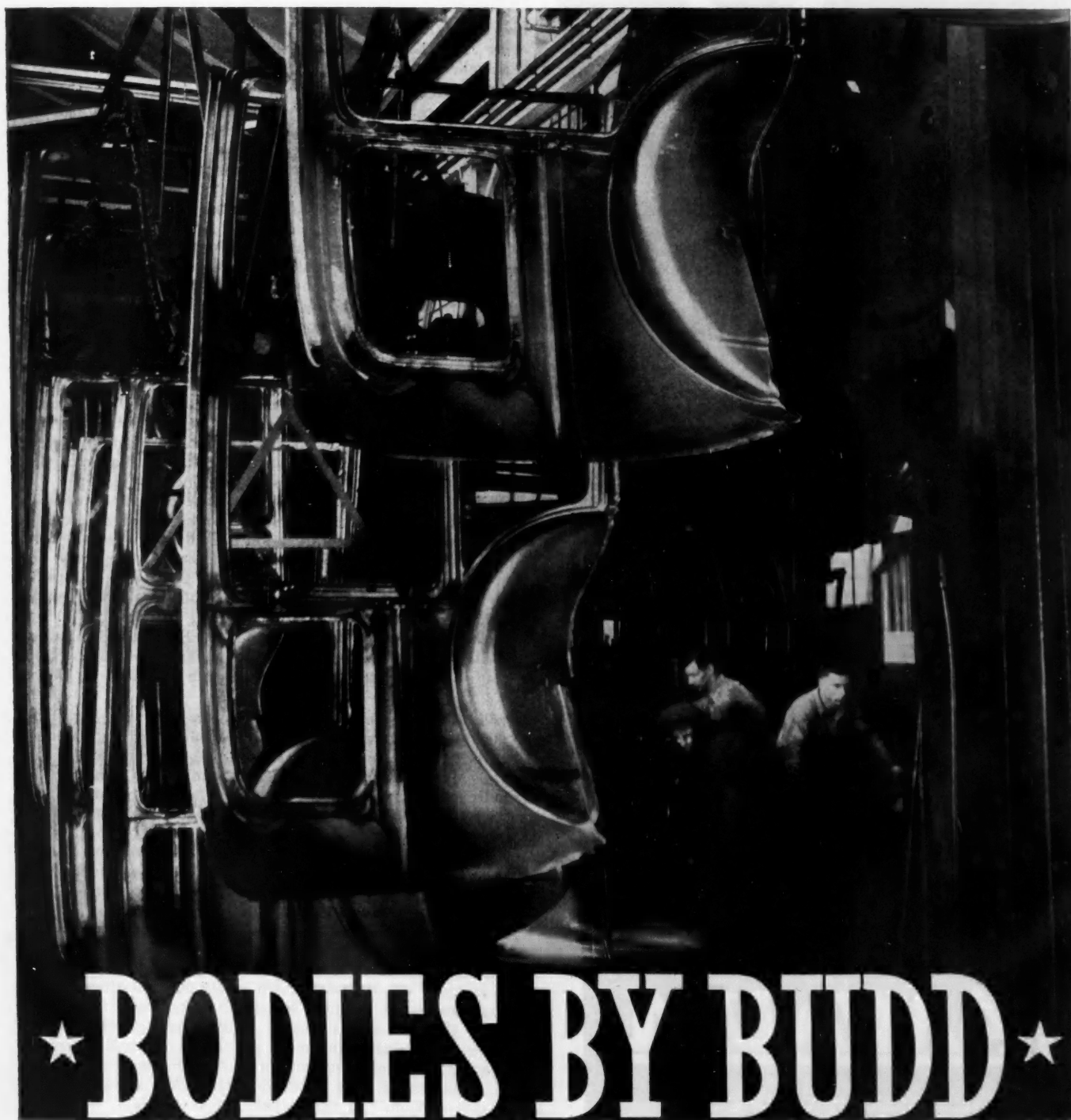
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Notes and Reviews

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from the use of a controllable-pitch propeller that will give good efficiency at all conditions of flight and also allow the full power of an engine to be developed when most needed will offset many times the disadvantage of a heavier propeller.

The difficulties encountered in the design and construction of controllable-pitch propellers are considered and pitch-indicating devices are discussed.

The paper closes with a brief outline of the better-known types of controllable-pitch propeller, including hand-control, brake-control, hydraulic-control and electric-control types; and the author predicts an increasing use of this form of propeller, probably with electric-motor control.

Les Tendances Actuelles de la Technique Aéronautique.

By A. Verdurand. Published in *La Technique Moderne*, March 1, 1931, p. 151. [A-1]

That aircraft technique is far from having reached a period of relative stability is the contention which the author wishes forcibly to impress upon his readers. While a unanimity of opinion on certain phases of aircraft design seems to exist, such unanimity is more apparent than real and is an outgrowth not of scientifically proved data but of vigorous propaganda. Aeronautic technique should not be allowed to crystallize until it has developed aircraft forms that, by the importance and security of the services they can render, will make themselves an essential and integral part of the economic life of the world.

In support of his thesis the author analyzes, first, the all-metal cantilever monoplane, which has attained widespread acceptance but still admits of competition from other less conventional types. Giant flying-boats, after a canvass of the possibilities so far realized, are condemned as a combination of a mediocre boat with an equally mediocre airplane. In the development of transoceanic aviation, effort should be concentrated on designing a craft that will avoid forced water-landings rather than one that will mitigate the dangers of such landings.

Several methods of framework structure for cantilever wings, designed to obviate torsional vibration, are described and semi-cantilever wings are suggested as a possible solution of this problem. Wood construction is said to be far from obsolescent, and information is given on a biplane form which avoids the disadvantages of wire bracing.

Versuche an einem Windkanalmodell. By Max Schilhansl. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Feb. 28, p. 107, and March 14, 1931, p. 147. [A-1]

Preliminary research to determine data on which to base the design of the wind-tunnel to be built for the German institute for aeronautical research is summarized in this article. In general, the tunnel is similar to that of the Zeppelin company at Friedrichshafen, except that the air passages, instead of being at each side of the test section, are above and below it, necessitating a cellar and an attic story. To determine the suitability of the proposed design and the engine and propeller requirements, a model was built and 103 series of tests, extending over a period of a year and a half, were made on it.

The model, a full description of which is given, was constructed so that every separate part that could influence the characteristics of the tunnel was removable, so that other sections of different form could be substituted and comparisons made. Three series of tests were run. The object of the first series was to attain, through changes in the tunnel form, the maximum efficiency of air-flow in an open-throat type of construction. A form was developed which, it is stated, can be used with either an open or a closed test-section. In the second series of tests, measurements were made of the velocity distribution across the air-

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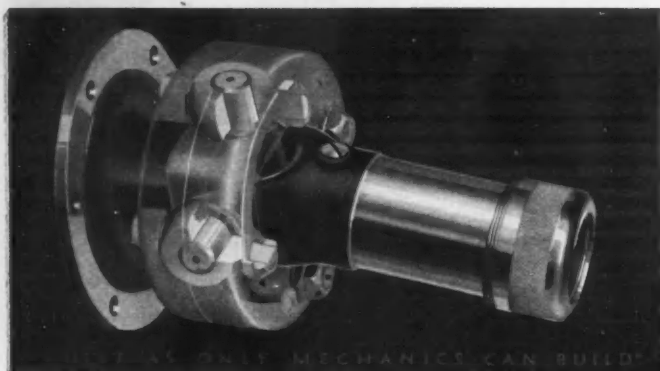


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Notes and Reviews

Continued

stream. Finally, methods of air-flow control were experimented with and a new form of regulation developed.

The Phenomenon of Buffeting. Published in *Aircraft Engineering*, February, 1931, p. 31. [A-3]

This article is a synopsis of the 92-p. detailed technical report on the accident to the Junkers F-13-type airplane which occurred at Meopham, Kent, England, on July 21, 1930. It gives a brief summary of the circumstances of the accident and the inquiries that led to rejection of a number of theories of the cause and the final conclusion that it was due to a phenomenon called "buffeting." This is defined as "an irregular oscillation of the tail unit, in which the tail-plane bends rapidly up and down and the elevators move in an erratic manner." It is caused by the eddies given off by the wings at large angles of incidence and is quite distinct from flutter, which, in the case of machines of the Junkers F-13 type, would develop only at a speed above 250 m.p.h. The investigation is more than interesting because no previous accident has been attributed to this cause.

Elmira Soaring Contest, 1930. By Wolfram K. E. Hirth, Martin H. Schempp and Jack Herrick. Technical Memorandum No. 613. Published by the National Advisory Committee for Aeronautics, City of Washington, March, 1931; 15 pp., 4 figs. [A-3]

The first American national soaring contest held at Elmira, N. Y., was a greater success than anyone had anticipated. This, the authors declare, was due to the quality of the pilots and airplanes and also to the very favorable terrain and the directions of the prevailing wind. This paper covering the detailed facts of the event was originally prepared at the request of the National Glider Association.

Some Approximate Equations for the Standard Atmosphere. By Walter S. Diehl. Report No. 376. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 12 pp., with tables and charts. [A-4]

This report, which was prepared for publication by the National Advisory Committee for Aeronautics, contains the derivation of a series of simple approximate equations for density ratios and for the pressure ratio in the standard atmosphere. The accuracy of the various equations is discussed and the limits of applications are given. Several of these equations are in excellent agreement with the standard values.

Bericht über den 11. Rhön-Segelflug-Wettbewerb. By Walter Georgii. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, March 14, 1931, p. 129. [A-4]

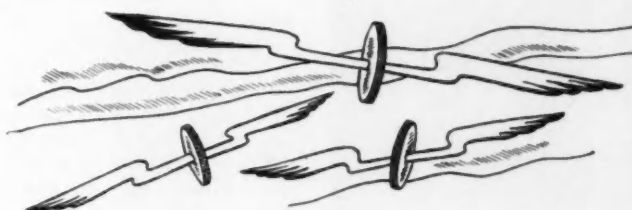
In spite of unfavorable economic and weather conditions, the 11th annual sailing-flight competition is asserted to have achieved signal success. Progress in motorless flight was demonstrated not so much by single records broken as by the large number of creditable performances, the greater number of pilots so distinguished and the small number of breakdowns.

Especially was this evidenced in the tests for flight duration. While in 1929 only two flights of more than 5-hr. duration were made, 12 flights passed this time limit in 1930 and, of these, 7 lasted more than 7 hr. In the longest single flight last year, the pilot kept his glider in the air for 8 hr. 36 min., which did not excel the record previously set. The three contestants leading in this series of events accumulated total flying times of 27½, 24½ and 16½ hr. respectively.

In the maximum altitude attained, the best performance in the 1930 competition also was below previous records, owing to unfavorable weather conditions. The greatest altitude reached was 1640 m. (5381.82 ft.), and the three winners of this event averaged, for five flights, altitudes

(Continued on next left-hand page)

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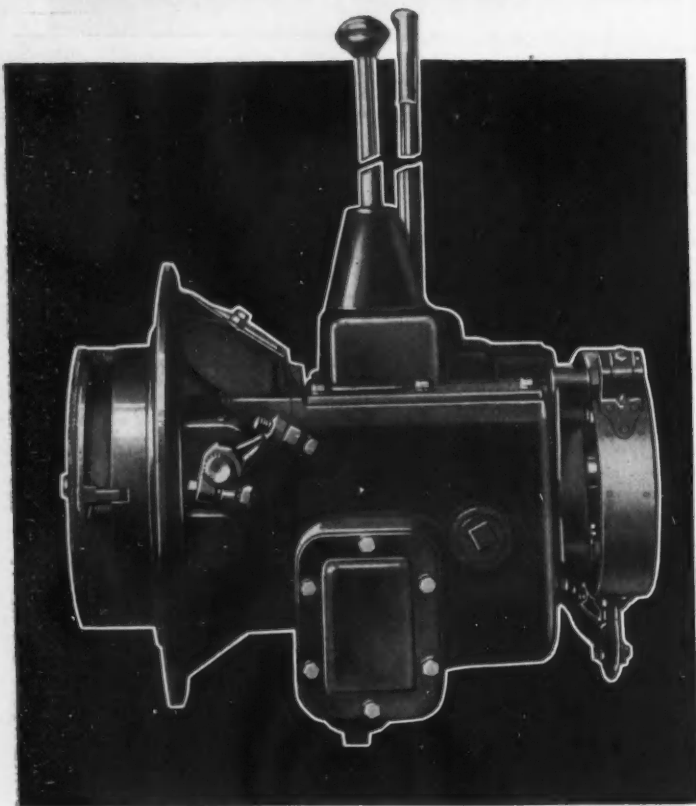
more valuable telephone service becomes to each subscriber. Unlike most other businesses, the telephone industry does not enjoy reduced costs as the number of customers increases. On the contrary, the trend is upward. To offset this, the American Telephone and Telegraph Company takes advantage of every scientific advance and aid to efficiency which can possibly reduce service costs — and these savings are used for the benefit of the subscriber.

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Notes and Reviews

Continued

of 734, 520 and 250 m. (2408.052, 2006.01 and 820.14 ft.).

In the event for maximum distance covered, the outstanding results for last year's competition were achieved. The two longest flights were 164.8 and 150.3 km. (102.4021 and 93.3964 miles), both made by the same pilot.

CHASSIS PARTS

Worm Gearing. By Prof. James J. Guest. Published in *The Automobile Engineer*, January, 1931, p. 29. [C-1]

As with most mechanical products, the quality of worm gearing has improved greatly during the present century. This is not only a matter of materials and processes of manufacture but of theoretical development brought about by a closer investigation of the action of such gearing. Thus, in the parallel type of worm gearing, various shapes of worm tooth have been discussed and experimented with, and, in the more truly hyperboloid type, the Hindley gear is being replaced, first, by the Lanchester gear of the Daimler Motor Co., and, later, by the gear invented by the author and manufactured by the Moss Gear Co.

In support of his theory of gear construction, the author quotes extensively from engineering authorities. He points out that gears of the Hindley type cannot be ground after hardening, but the Guest gear is finished to shape by grinding and its parts are accordingly interchangeable.

Gearbox Design. By R. Dean-Averns. Published in *The Automobile Engineer*, December, 1930, p. 485. [C-1]

This paper is a survey of the problems involved. Elimination of noise is the problem that gives rise to the greatest concern. Gear-wheel noises fall into three general categories:

- (1) A whine or ring
- (2) Those producing a low growl
- (3) Those emitting an irregular "hammer."

It is believed that "bounce," or rebound, of the teeth in mesh is responsible for the majority of tooth noises. Eccentricity of bore has a decided bearing upon growl, as it produces a constant repetition of relative pitch and profile error. One of the main causes of whine seems to be that of web vibration due to general finish of the gears and rough spots on the teeth.

Silence, length of life and service all influence the selection, although it is generally supposed that the 20-deg. pressure angle offers numerous advantages over the earlier design of 14½-deg. tooth, which was adopted in connection with the rotary-type cutter. The double helical gear provides greater silence in operation and obviates the undesirable end thrust which is occasioned by the single helical tooth and dog-clutch-operated gear. The true tooth profiles of the spur and the helical gear are identical, but, while with the spur gear contact takes place on a line through the pitch point of the tooth, with the helical tooth this line extends diagonally across the tooth face, and this introduces the important question of comparative strength, wear and silence.

Why Did That Spring Break? By E. E. Thum. Published in *Metal Progress*, March, 1931, p. 56. [C-1]

Spring failures, according to the author, may be due to three general causes: (a) poor engineering design; (b) poor material or faulty heat-treatment of good material; and (c) use of the wrong kind of material to withstand the service conditions.

Engineers in general do not calculate the stresses in the springs they order but simply rely on handbook tables, Mr. Thum contends; consequently the commonest cause of trouble with springs is overloading. The calculation of stresses is considered at some length, together with the other problems involved in spring making.

The author deals only with tension and compression springs.

(Continued on next left-hand page)



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Notes and Reviews

Continued

L'Équilibrage des Freins. By M. Duwoos. Published in the *Journal de la Société des Ingénieurs de l'Automobile*, February, 1931, p. 1258. [C-4]

Assuming that previous papers have covered amply the technical aspects of brake design and layout, the author devotes his observations to the more practical question of adjustment. He points out that accurate adjustment can never improve on the efficiency of a given brake; it can serve only to maintain the performance provided for in the original design. Moreover, all adjustments, he says, should be strictly guided and controlled by brake tests.

This raises questions as to what is the proper criterion for brake effectiveness. Stopping distance is not regarded favorably by the author, since he believes that this figure, in spite of its practical aspect, is in reality purely theoretical and not susceptible of accurate measurement. He prefers to use the braking coefficient, which, being independent of the weight of the vehicle, permits comparisons of the braking efficiency of different types of vehicle. In addition, this value may be easily ascertained, both by calculation and measurement. He refers to certain published figures which, he says, indicate that American cars have braking coefficients ranging from 0.45 to 0.27, with an average of 0.29, whereas his measurements of French vehicles have indicated braking coefficients of 0.35 to 0.40.

He emphasizes the necessity of standardizing on some method of indicating braking efficiency and describes the following brake-testers: the English Linendoll, Harvey Frost and Laycock; the American Patterson, Cowdrey, Jumbo, Raybestos, Bean and Weaver, and the French Freinomètre developed by the Técalemit company.

ENGINES

Effect of Orifice Length-Diameter Ratio on the Coefficient of Discharge of Fuel-Injection Nozzles. By A. G. Gelalles and E. T. Marsh. Technical Note No. 369. Published by the National Advisory Committee for Aeronautics, City of Washington, March, 1931; 14 pp., 11 figs. [E-1]

The variation of the coefficient of discharge with the length-diameter ratio of the orifice was determined for injection nozzles having single orifices 0.008 and 0.020 in. in diameter. Ratios from 0.5 to 10 were investigated at injection pressures from 500 to 5,000 lb. per sq. in.

The tests showed that, within the error of the observation, the coefficients were the same whether the nozzles were assembled at the end of a constant-diameter tube or in an automatic injection valve having a plain stem. For these assemblies the coefficient was constant between the ratios of 1 and 4. For ratios greater than 4 the coefficient gradually decreased as a result of friction losses.

The coefficients of the nozzles when assembled in an injection valve having a helically grooved stem were lower than when assembled with a plain stem. There was but little variation in the value of the coefficient with the ratio for the 0.020-in. orifice. The coefficient for the 0.008-in. orifice, however, varied considerably with the ratio, showing some irregularities between the ratios of 0.5 and 4.0.

Coefficients of Discharge of Fuel-Injection Nozzles for Compression-Ignition Engines. By A. G. Gelalles. Report No. 373. Published by the National Advisory Committee for Aeronautics, City of Washington, 1931; 19 pp., with tables and charts. [E-1]

This report presents the results of an investigation to determine the coefficients of discharge of nozzles with small, round orifices of the sizes used with high-speed compression-ignition engines. The injection pressures and chamber back-pressures employed were comparable with those existing in compression-ignition engines during injection. The

(Continued on second left-hand page)



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Since Hydraulics were first offered to the industry, engineers have realized their advantages; since their first trial by customers, they have held an enviable public endorsement. It's quite an advantage to a salesman when he and his prospect see "eye to eye"—as in the case of Lockheed Hydraulic Brakes.

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Notes and Reviews Continued

construction of the nozzles was varied to determine the effect of the nozzle design on the coefficient. Tests were also made with the nozzles assembled in an automatic injection valve, with both a plain and a helically grooved stem.

It was found that a smooth passage before the orifice is requisite for high flow-efficiency. A beveled leading edge before the orifice gave a higher coefficient of discharge than did a rounded edge. Varying the length-diameter ratio from 1 to 3 for one of the orifices having a beveled leading edge was found to have no effect on the value of the coefficient. The results with the nozzles assembled in an automatic injection valve having a plain stem duplicated those with the nozzles assembled at the end of a straight tube of constant diameter. Lower coefficients were obtained with the nozzles assembled in an injection valve having a helically grooved stem.

When the coefficients of nozzles of any one geometrical shape were plotted against values of corresponding Reynolds numbers for the orifice diameters and rates of flow tested, it was found that experimental points were distributed along a single curve.

The Mechanism of the Atomization of Liquids. By R. A. Castleman, Jr. Published in the *Bureau of Standards Journal of Research*, March, 1931, p. 369. [E-1]

A discussion is given of the general problem and of some applications of the phenomena of liquid atomization, with especial reference to fuel preparation in internal-combustion engines. The author points out that both "air" and "solid" injections seem to have physical backgrounds quite similar to that of airstream atomization, and the discussion is limited to the latter.

Some previous work which seems to bear either directly or indirectly on this problem is reviewed, and it is assumed that a necessary step in atomization is the tearing of ligaments from the unatomized mass, these ligaments being of such sizes that they will eventually break up into drops of the sizes observed in the spray.

Brief discussions are given of the applicability of Rayleigh's work on the rate of collapse of liquid columns to the collapse of these ligaments.

Improvement and Economy in Carburetor Control. By F. A. Holt. Published in *Aviation Engineering*, February, 1931, p. 21. [E-1]

The Hutchinson Laboratory has developed a simple, compact instrument called the Moto-Vita. When this is attached to any internal-combustion engine, it gives a continuous indication of the percentage of combustibles present in the exhaust gas.

With this exhaust-gas indicator installed on an airplane, the pilot has an accurate gage to indicate, not only an economical mixture, but also one that will cause no overheating of the engine. Thus the gasoline economy of an airplane is improved.

Prospects of the Oil Engine. By H. O. Farmer. Published in *The Commercial Motor*, Dec. 16, 1930, p. 599. [E-1]

The compression-ignition engine has been developed as a prime mover for industrial purposes until it is now the most efficient heat engine. The main reason for the higher efficiency of the oil engine lies in its higher expansion-ratio, since it employs a compression ratio of about 14:1, against 5:1 of the gasoline engine.

The author describes four types of combustion chambers; namely, open or non-turbulent, pre-combustion, combustion chamber separated from the working cylinder by a neck or restriction, and rotational swirl, which is best employed in conjunction with a sleeve valve.

(Continued on next left-hand page)

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Notes and Reviews

Continued

The compression-ignition oil engine has its good points but also has its disadvantages. It is difficult to start. It cannot make use of the whole of the oxygen of the air charge and so, in spite of its higher expansion-ratio, cannot develop the same power per unit of cylinder capacity as the gasoline engine, therefore it must have a higher weight-to-power ratio, which will increase the cost of manufacture.

Recent Developments in Engine Cooling. By Andrew Swan. Published in *The Journal of the Royal Aeronautical Society*, March, 1931, p. 179. [E-1]

The author points out that the problem of effective cooling of an aircraft engine is inseparably associated with the requirement of small drag. The paper describes work on engine cooling having as its primary object the reduction of drag with, if possible, no detrimental effect on engine operation and no loss in cooling efficiency.

Liquid coolants other than water were considered, and a limited number of tests using ethylene glycol and glycerin were conducted at the Royal Aircraft Establishment. These substances were chosen because they are readily available in bulk at a reasonable cost and have most of the properties required of a coolant. Results of these tests are given, comparing the ethylene-glycol-cooled engine with a water-cooled engine as to effect on engine power, operating temperatures and drag.

A series of flight tests were also made using an evaporative cooling system fitted to a Falcon engine in a Bristol fighter, first with a honeycomb radiator and later with wing condensers. Diagrams of the set-up are included in the article, with some notes on cooling the lubricating oil.

Le Graissage des Cylindres par Mélange d'Huile et d'Essence. By Henri Petit. Published in the *Journal de la Société des Ingénieurs de l'Automobile*, February, 1931, p. 1267. [E-1]

In discussing upper-cylinder lubrication by oil mixed with the fuel, the author first mentions the necessity of lubricating this part of the engine and of the difficulty of securing such lubrication with the conventional lubrication system. However, he deprecates what he regards as the exaggerated claims made for the benefits of upper-cylinder lubrication and for the qualities of the oils recommended for this purpose.


Resistance to both extremely high and low temperatures is one of the qualities claimed for the oils, which he does not think is justifiable, and, to prove his assertion, he quotes results of tests made. In his opinion, the extremely high flash and fire-points claimed are not a necessary property for these lubricants. However, the oils must be of a quality to form a homogeneous mixture with the fuel and to resist dissociation. The oils examined by him have fulfilled these conditions.

Other benefits claimed for the mixture of oil with the fuel, such as increase of engine power and reduction of detonation, should, he believes, be investigated by car manufacturers, and he suggests the nature of tests to be made for this purpose. He gives figures intended to show that the use of upper-cylinder lubricants practically doubles the oil consumption of the engine.

Finally, he points out that all lubricants so far recommended have been liquid, for the most part mineral oils or compound oils. He suggests that tests be made to ascertain the possibility of using graphite.

Modern Diesel-Engine Practice. By Orville Adams. Published by the Norman W. Hanley Publishing Co., New York City, 1931; 656 pp. Price, \$6. [E-4]

Heretofore the Diesel engine, in the minds of most people, has taken on the form and substance of the mysterious, (Continued on next left-hand page)




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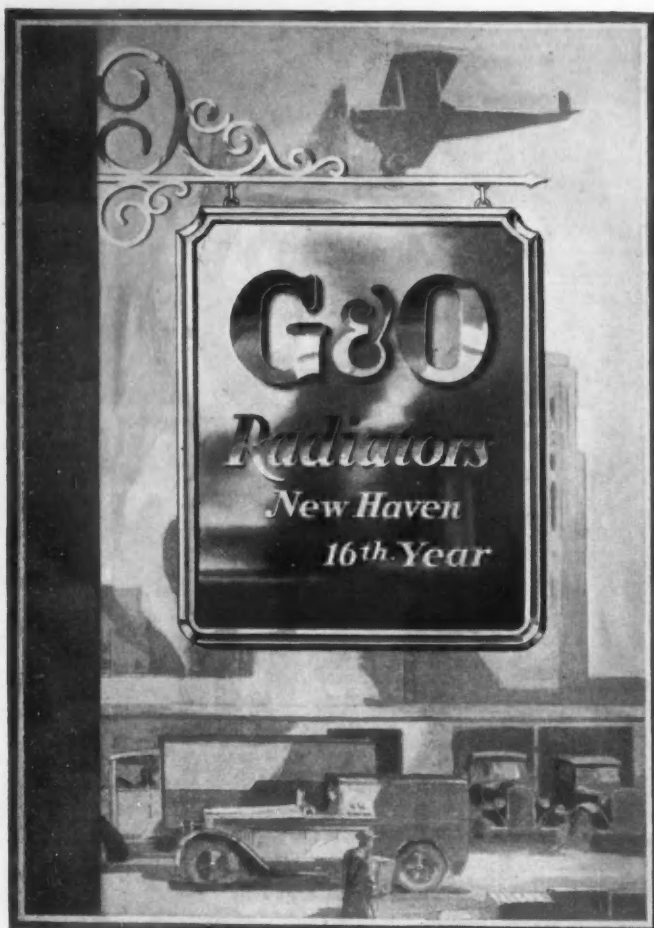
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Notes and Reviews

Continued

obscure and incomprehensible. Engineers, like the author, have found by study and experience that it is even more simple and perfect in its action than the gasoline engine.

This book on Diesel-engine operation and practice is a combined reference book on construction and design, with a practical operator's manual. It is the result of a great deal of thought and research, supplemented with considerable personal experience. The fields of application and past history of this efficient and comparatively new prime mover; its general and special operating principles; the construction and design of the different types of Diesel engine, as well as the best practice in modern Diesel-engine installation, operation and maintenance practice, operating costs, repair and upkeep, are considered at length. Two chapters are devoted to the Packard aircraft Diesel. The concluding chapter discusses the possibilities of the Diesel application to automobiles and tractors, especially the Cummins Diesel, the design and operation of which are familiar to most S.A.E. members, since a paper by the inventor was published in the S.A.E. JOURNAL, October, 1927, p. 388.

MATERIAL

Engineering Materials, Vol. III—Theory and Testing of Materials. By Arthur W. Judge. Published by Isaac Pitman & Sons, New York City, 1930; 498 pp., indexed and profusely illustrated. Price, \$6. [G-1]

Of especial interest to engineers because of a new and well illustrated chapter on testing machines and testing methods, including hardness and hardness-testing machines, abrasion and wear tests, the testing of cast iron, modern theories of materials, and optical methods of stress determination, as well as a new section dealing with the properties of metals of high temperature, is this new English book on engineering materials by Arthur W. Judge. The author explains that the present volume is a thoroughly revised and extended account of the section of the author's *Aircraft and Automobile Materials, Vol. I (Ferrous)*. The complete work now includes three volumes: Vol. I, covering *Engineering Materials (Ferrous)*; Vol. II, *Aircraft and Automobile Materials (Non-Ferrous and Organic)*; and Vol. III, *Engineering Materials (Theory and Testing)*.

This book, while not exhaustive, covers briefly types of stresses and discusses strain and elasticity, the properties of materials under test, the testing of cast iron, the fatigue strengths of metals, and stress formulas for design work. B.E.S.A. heat-treatment definitions and mechanical-test requirements, high-frequency fatigue effects in materials and miscellaneous related tables make up the appendices.

Wear of Metals. By Samuel J. Rosenberg and Harry K. Herschman. Published in *Metals and Alloys*, February, 1931, p. 52. [G-1]

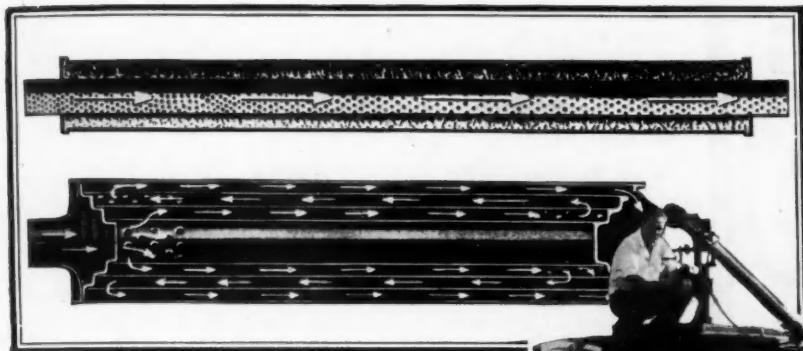
The authors are associate metallurgists of the Bureau of Standards. In this article they describe briefly (a) the types of wear, rolling and sliding friction; (b) some of the better known testing machines; (c) the difficulties encountered in wear testing, and (d) the factors commonly encountered in the application to service of results obtained in the laboratory.

It has been recognized by many investigators that there is no "best" wear-resistant material for all types of service and conditions. This is because of the variations in conditions of service, therefore there can be no universal wear-test.

The important factors affecting the wear of metals are the metals themselves and the conditions of service. Under the first group would come such items as metallurgical origin, chemical composition, casting conditions, conditions of working, presence or absence of impurities, grain size, constitution and heat-treatment. The second group would

(Continued on next left-hand page)

BURGESS MUFFLER *f*acts



"Above—The full power muffler (upper) absorbs sound waves while offering little or no resistance to the passage of exhaust gases. Compare with the complicated passage in the conventional muffler (lower) which sets up engine back pressure and reduces effective horsepower."

"Right—The sensitive microphones of sound movies have an annoying habit of over-emphasizing the 'voices' of most automobiles. In filming 'The Third Alarm' Tiffany tried various kinds of expensive cars in the unsuccessful effort to find one which really sounded suave and expensive. Finally, Paul Hurst, one of the stars of the production, offered his own President Roadster for a sound-test. Of all cars tried, its voice was the most refined and pleasant in the 'play-back'—carburetor silencer, exhaust silencer, silent transmission and quiet valve mechanism eliminating all roar and clatter."



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Notes and Reviews

Continued

consider factors such as material with which the metal is in contact, contact pressure, abrasion speed, duration of abrasion period, condition of surface, presence or absence of lubricants, coolants, abrasives, film, operating temperature, and stress-corrosion effects.

At the end of the article there is a selected bibliography on wear of metal.

What Is This Thing Called Fatigue? By H. W. Gillett. Published in *Metals and Alloys*, February, 1931, p. 71. [G-1]

Most of the failures in springs, axles, shafts, connecting-rods and other moving parts made of metals do not come as a result of a smash-up but are caused by the continued repetition of stresses so low that their effect would be inappreciable if they were not repeated.

Research has shown that steels and ferrous alloys in general have a true endurance limit. Tests to determine these limits are carried on in research laboratories all over the world. Testing methods of various descriptions have been worked out and extensive investigations have been made, but difficulties crop up. In spite of all the drawbacks, the need for the results of endurance testing is so plain and the value of the results so great that the engineers persevere in their research to discover simpler and, if possible, less expensive methods for testing the endurance limit of metals.

Economics of Tungsten. By Paul M. Tyler. Published in *Metals and Alloys*, February, 1931, p. 80. [G-3]

Tungsten has been one of the dominant factors in the era of mass production. Its greatest use is in the steel industry, chiefly in high-speed steel and to a less extent in other tool steels and in magnet steels. Tungsten carbide is the hardest of man-made materials. It is used as an alloy in non-warping valves for internal-combustion engines, especially for airplanes; in incandescent-lamp filaments, and so forth. Tungsten deposits are sparsely distributed throughout the world and even in individual deposits the occurrence of tungsten minerals is notoriously erratic. The deposits do not play out but, as mining advances further and further below the surface, prospecting becomes more expensive. First one country and then another has attained world leadership only to relinquish it as prices change. For several years China has been the principal source of the world's tungsten supply, but in 1929, when tungsten roughly trebled in price, other countries, notably Burma, Bolivia, Portugal and the United States, took steps to increase production.

MISCELLANEOUS

The Automobile Engineer's Pocket Book. By H. Kerr Thomas. Published by Spon & Chamberlain, New York City, 1931; 126 pp. Price, \$2.50. [H-3]

The author is a noted engineer and past-president of the Institute of Automobile Engineers in England. In this book he presents a collection of standard methods of calculation which will be useful to automobile engineers, draftsmen and others engaged in the automobile industry. They will save much time, and greater accuracy will be attained if the elements of each unit comprising a chassis are dealt with in a systematic way. Many of the tables included are published for the first time.

The Manly Family. Compiled by Louise Manly. Published by the Keys Printing Co., Greenville, S. C., 1930, 351 pp. [H-3]

Of especial interest to members of the S.A.E. is a privately printed book, *The Manly Family*, containing in chapter 19 a biographical sketch of Charles Matthews Manly, inventor and pioneer in aviation and a former President of the Society. The chapter is an interesting summing up of the work of this eminent member of the engineering profession.
(Concluded on next left-hand page)

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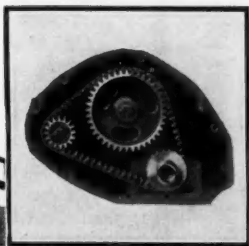
Foreign

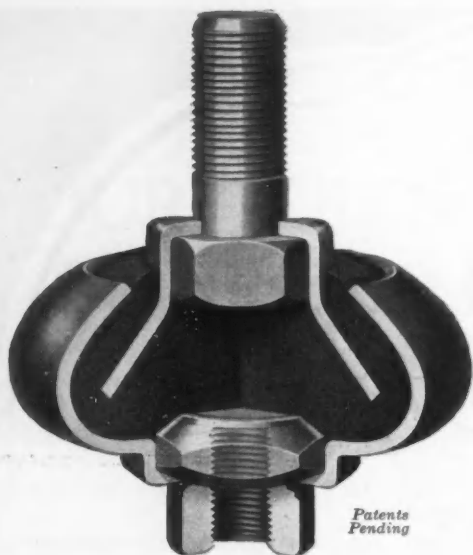
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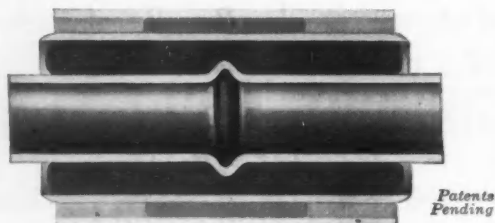
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Notes and Reviews

Concluded

neering world and traces his career from his graduation from Cornell in 1898 through his several activities with Dr. S. P. Langley, Glenn H. Curtiss and the English and United States Governments to the posthumous award of the Langley Medal for Aerodynamics on Dec. 12, 1929. Early recognized as a brilliant student by Prof. R. H. Thurston, head of Cornell's Engineering Department, he was chosen by Dr. S. P. Langley as his chief assistant in the pioneer work in aviation then being carried on at the Smithsonian Institution at Washington.

Chief among the problems which confronted young Manly was that of the construction of an engine powerful enough to drive the plane through the air, light enough to come within the rigid weight requirements, and smooth and reliable enough to be depended upon in this hazardous undertaking. After manufacturers had failed, Charles Manly himself designed and built an internal-combustion engine that is regarded by the greatest authorities as one of the most remarkable achievements in the history of engineering and aviation—a five-cylinder rotary type weighing only 124 lb., which developed under rigid tests 52 b.hp. continuously for 10 hr. No gasoline engine of equal power in proportion to weight was built until 16 years later.

MOTORCOACH

The Büessing Six-Wheeler. Published in *The Automobile Engineer*, January, 1931, p. 3. [J-1]

The Büessing six-wheeler is made in two models. The main difference between them is that one has a straight high frame, while the other is swept down behind the power unit to give a low floor-level. The latter model is fitted with an engine developing 110 hp., while the straight-frame chassis has an engine developing 90 hp. Both engines have six cylinders and are practically identical except for bore and stroke dimensions.

The engine power is transmitted through a cone-type clutch to the four-speed transmission. One of the most extraordinary features of the design is the dual propeller shafts.

The article is accompanied with drawings of the engine and chassis parts, which are well worth study.

MOTOR-TRUCK

A Résumé of Three Years of Reducing Costs of Operating Automotive Equipment. By James C. Bennett. Paper presented at annual meeting of the American Petroleum Institute, Chicago, November, 1930. [K-2]

The author is out to sell an idea; namely, that a company operating a fleet of considerable size would find it profitable to have an automotive department whose function is to supply appropriate vehicles to any and all departments that may have use for such equipment, and of maintaining that equipment in a condition which will assure its being ready at all times to meet all reasonable demands that may be put upon it by the department to whose use it has been assigned.

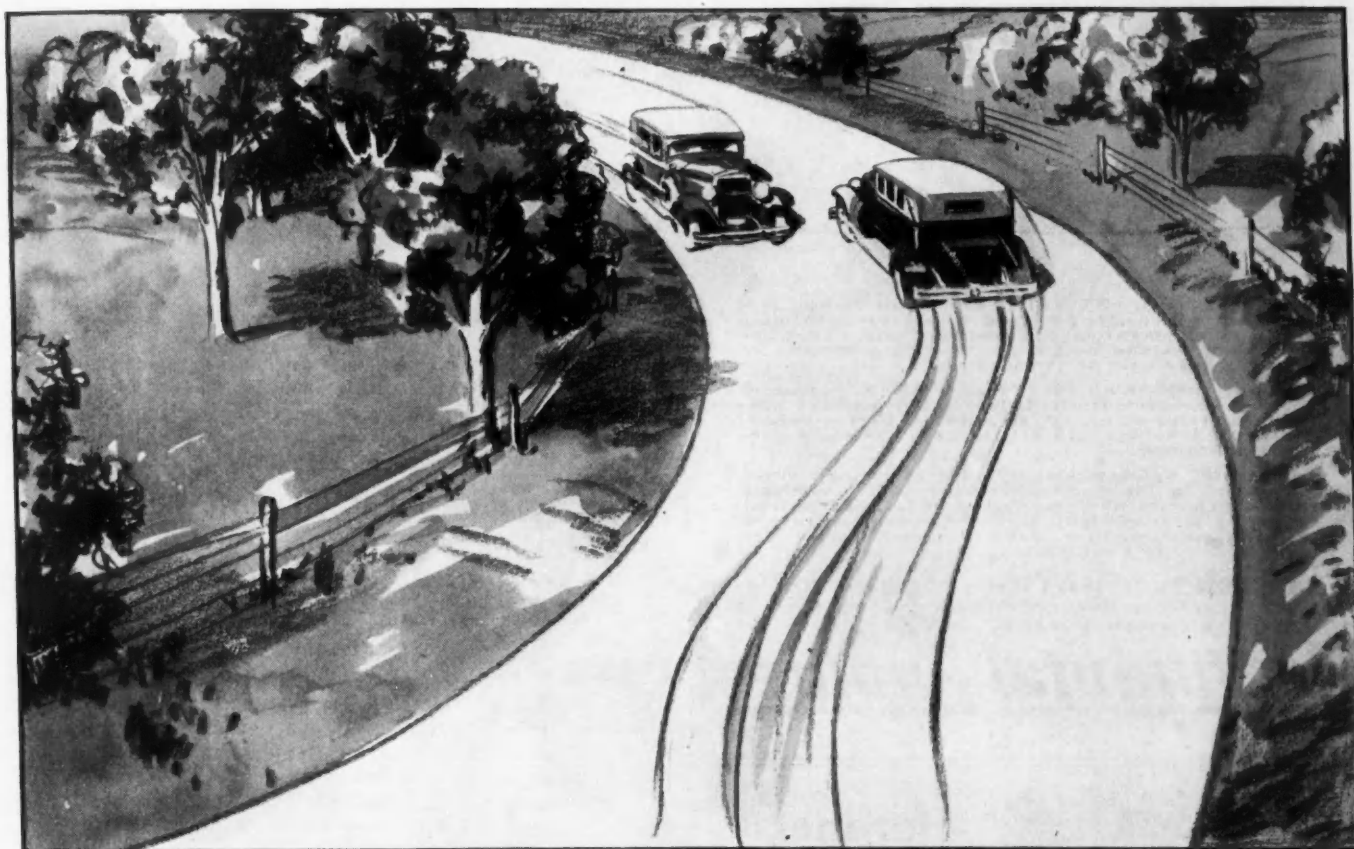
The costs of such a department are assessed against the operating department through the medium of a schedule of rates per mile, graded according to the capacity of the vehicle.

Expenses incurred on account of drivers' compensation or accidents traceable to any cause which is reasonably within control of the driver are assessed directly against the department in whose service the driver or vehicle is employed.

On the other hand, accidents traceable to mechanical failures of the equipment are absorbed by the automotive department as a portion of its operating expense.

Mr. Bennett gives in detail explanations of statistical charts; factors of expense, for example, storage, rental rates, labor required for maintenance and repairs, painting, washing and greasing; all materials, including tires and maintenance; gasoline and oil, also indirect expense such as depreciation, taxes, insurance and retirement loss.

High Speed Steering

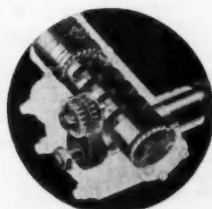


• *Today's high driving speeds demand steering gears built to handle high speed safely. At sixty or better there's no time for delayed responsiveness . . . for uncertainty that saps the driver's confidence . . . High speeds demand instant response.*

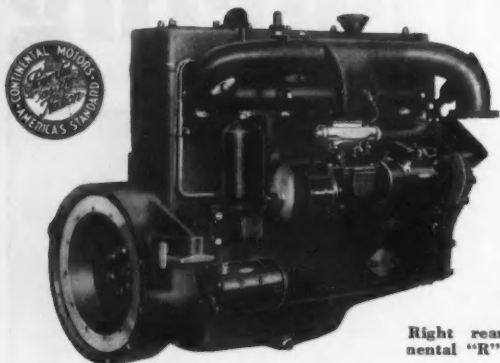
Because of its accuracy of manufacture, its extreme ease of wheel-turn, the Ross Roller-Mounted Cam and Lever Steering Gear is always swift and sure in its response to the driver's direction. Lack of friction has reduced wear to a negligible point in this most advanced of steering gears. Yet when wear does occur, this gear can be adjusted with such precision as to maintain its original accuracy and responsiveness throughout the life of the car. High speed requires just as good steering at 20,000 miles as it does when the car is new. Ross gives it.

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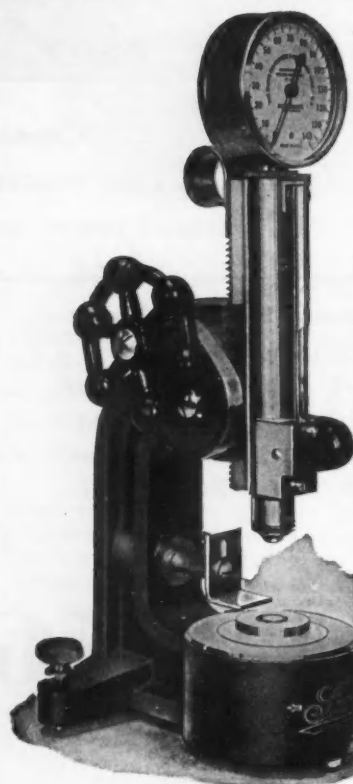
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Personal Notes of the Members

(Continued from p. 603)

the General Motors Truck Co., of Pontiac, Mich., has been elected vice-president in charge of the motorcoach division of the General Motors Truck & Coach Co. of Canada, Ltd., of Walkerville, Ont., Canada.

R. M. Garrison, a former student operator with the Du Pont Rayon Co., of Old Hickory, Tenn., is now an instrument tester with the Houston Lighting & Power Co., of Houston, Texas.

Announcement has been made of the resignation of F. M. Germane, as president of the Bearings Co. of America, of Philadelphia. Mr. Germane has not divulged his plans for the future.

Felix Haas is now employed as a designing and development engineer for shop machinery with the Superheater Co., of East Chicago, Ind.

V. F. Halliburton, who was formerly stationed at the United States Naval Reserve, Aviation Base, Grosse Ile, Mich., is now manager of portable fire-extinguisher and electric-furnace sales for James E. Walsh & Associates, of Detroit.

Mark Harris has terminated his services with the H. H. Franklin Mfg. Co., of Syracuse, with which he has been connected as manufacturing and research engineer for the last two and one-half years. Prior to that time he was with the General Motors Corp. in various engineering capacities for a number of years. Mr. Harris has not announced his plans for the future.

Thomas J. Little, Jr., was recently elected vice-president and a director of the Holley Carburetor Co., of Detroit, which is one of his clients in his consulting engineering practice. He recently returned to Detroit from Indianapolis, where he had been called by the Marmon Motor Car Co. to reorganize its engineering department and completely redesign its product. Mr. Little has been successively engineering executive of the Lincoln Motor Car Co. and the Marmon Motor Car Co. and is a Past-President of the Society.

Charles D. McCall is now acting as sales manager for the Muncie Products Division of the General Motors Corp., at Detroit. He previously served the firm of Manning, Maxwell & Moore, Inc., of Detroit, as district manager.

Merrit A. Mieras has severed his connection with the Detroit Aircraft Corp. as engineer on engine installations and is now employed by the Burgess Battery Co. in its Detroit office in a sales and engineering capacity.

A. W. Mooney has resigned his Chairmanship of the Wichita Section of the Society owing to his removal to Marshall, Mo., where he is engaged as an aeronautic engineer for Nicholas Beazley. He is president of the Mooney Aircraft Corp., of Wichita, Kan.

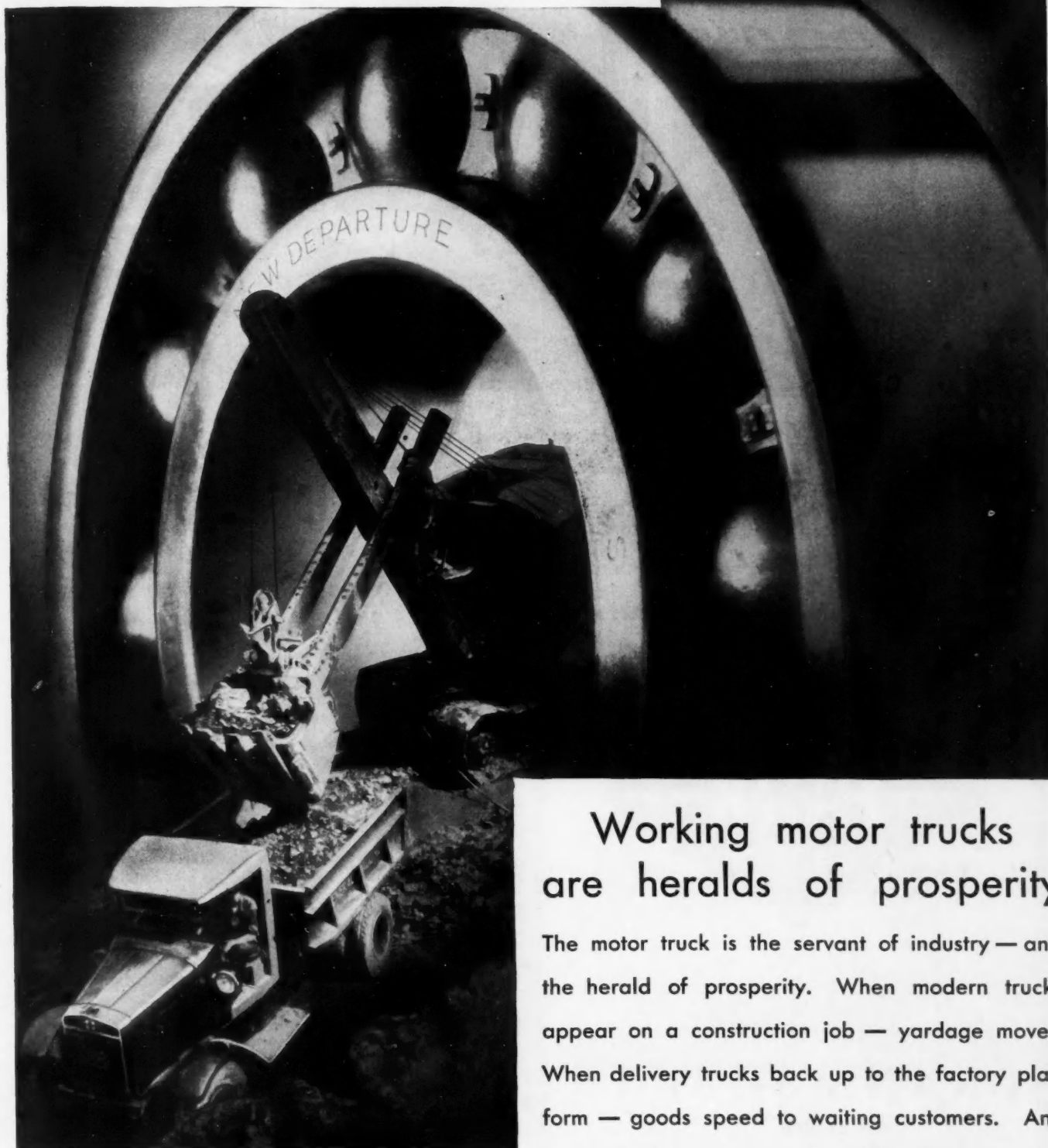
J. A. Moon has left the employment of Rolls-Royce of America, Inc., at East Springfield, Mass., and gone to England, where he is connected with the Midland Bank, Ltd., of Derby, England.

Leonard Ochtman, Jr., is now engineer for the S. R. Dresser Mfg. Co., of Bradford, Pa., in connection with the development of new products. Before assuming his new duties he was chief engineer of the Elco Works of the Electric Boat Co., of Bayonne, N. J. Mr. Ochtman is Chairman of the Motorboat and Marine Engine Division of the Standards Committee of the Society.

Yoshio Ogawa, formerly consulting engineer and general manager of the International Engineering Exchange, of Los Angeles, was recently appointed United States representative for the *Industrial Daily News*, of Osaka, Japan,

(Concluded on next left-hand page)

NEW DEPARTURE BALL BEARINGS



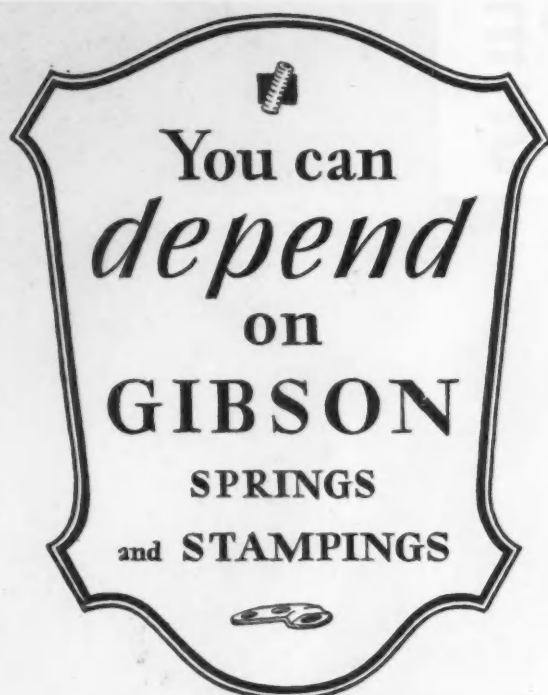
1713

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Personal Notes of the Members *Concluded*

and is owner of the Ogawa Co., which imports and exports automotive products.

A. S. Otton has relinquished his position as sales manager of the Hurley-Townsend Corp., of New York City, and is now assistant sales manager for the New York Lubricating Oil Co.

A. M. Sargent was recently elected to the presidency and general-managership of the Pioneer Engineering & Mfg. Co., Inc., of Detroit. Before that he was general manager of the Michigan Machine Co., also of Detroit.

Frank M. Say, former base maintenance manager for the New York, Rio & Buenos Aires Lines, Inc., at Miami, Fla., is now a partner in the firm of McGeachy & Say, airplane and engine mechanics, of Tampa, Fla.

Carl Schulz has secured a position with the dynamics section of the General Motors Laboratories, at Detroit, having left his position as a mechanical engineer in the development department of the Eastman Kodak Co., of Rochester, N. Y.

Norman G. Shidle, directing editor of the Chilton Class Journal Co., of Philadelphia, has been made a director of United Business Publishers, Inc., by which the Chilton organization is controlled. Mr. Shidle is a Councilor of the Society and Chairman of the National Meetings Committee.

Earl H. Smith has been transferred from his post as assistant chief engineer at the Olds Motor Works, in Lansing, Mich., to a similar post with the Oakland Motor Car Co., at Pontiac, Mich.

Charles W. Staples, having resigned as associate engineer with the United States Bureau of Standards, of the City of Washington, has accepted a position as research engineer with the Vacuum Oil Co., of Paulsboro, N. J.

Walter H. Titsch, a former engineer with Rolls-Royce of America, of Springfield, Mass., is now employed by the Packard Motor Car Co., of Detroit.

Walter Trefz recently assumed the duties of experimental engineer with Aluminum Industries, Inc., of Cincinnati. He was formerly a sales engineer with the Climax-Jones & Quinn Co., Inc., of St. Louis.

Ralph H. Upson is at present devoting most of his time to research and engineering work in association with William B. Stout at the Stout Engineering Laboratories in Dearborn, Mich. They are working on some interesting new developments that he hopes will soon be brought to light. In addition, Mr. Upson is doing a little teaching as a member of the faculty of the University of Michigan, at Ann Arbor.

C. F. Willich, a Foreign Member of the Society, has relinquished his post as technical director of the C. D. Magirus Co., at Donau, Germany, and is now associated with the Austin Motor Co., Ltd., of Northfield, Birmingham, England.

Lewis A. Wright has been engaged as patent attorney for the A. B. Dick Co., of Chicago. He formerly was assistant patent counsel for the Packard Motor Car Co., of Detroit.

1931 Summer Meeting

June 14 to 19, 1931

White Sulphur Springs, W. Va.